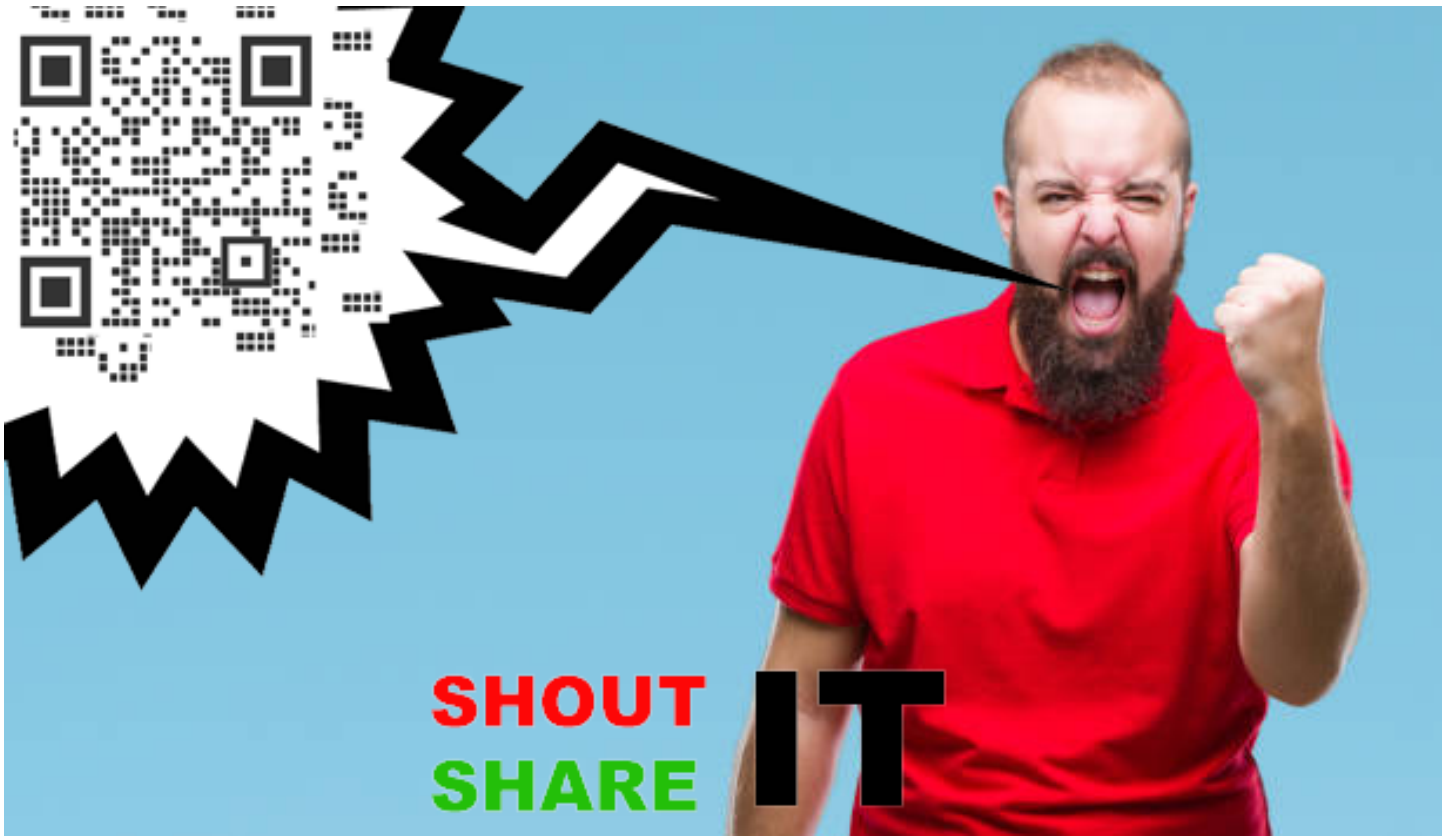
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THE UNIVERSITY OF KANSAS
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VOL. XXXVII, PT. I] OCTOBER 15, 1955 [NO. 1

The Effects of Internal Radiation from the Mothers Milk upon the Spleen of the Young Albino Rat [1]

BY

PAUL G. ROOFE and WALTER W. HAIR [2]

ABSTRACT: Adult female albino rats were injected intraperitoneally with approximately 30 micrograms of radium chloride. The females and their litters were sacrificed at specific time intervals from four to fifty-two days after birth. The spleens of the litter animals were examined quantitatively on the basis of percentage composition for comparison of constituent cells. A study of the peripheral blood was also made just preceding death. The results of these studies have been stated and shown graphically. The following are the most striking results:

1. The consumption of radium chloride through the milk of the mother by the young rats causes changes in the splenic tissue of the rats. These include loss of condensed splenic nodules, and a displacement of cell function and nuclear organization.
2. The alpha irradiation from radium chloride caused considerable disturbance in the relative quantities of the cellular constituents of the spleen. These changes include:
   (*a*) An increase in the number of macrophages and an invasion by these macrophages into the former splenic nodules;
   (*b*) A breakdown and destruction of erythrocytes which in turn were phagocytized by the reticuloendothelial cells;
   (*c*) An increase in the amount of granulocytic myelopoiesis with a particular increase in eosinophile myelocytes;
   (*d*) A decrease in the number of lymphocytes present, varies inversely with the number of macrophages present;
   (*e*) An increase in the number of megakaryocytes with heavy concentration around the periphery of the organ.
3. The alpha radiation from radium chloride caused peripheral blood damage which includes:
   (*a*) A lowering of the white blood count below that of "normal."
   (b) An increase in the number of normoblasts present in the peripheral blood.

1. (Work done under contract with the Office of Naval Research. N6 ori 220 T. O. 1)
2. Department of Anatomy, University of Kansas, Lawrence, Kansas.

4. The effect of the radiation on the weight of the animals was dramatic, showing a distinct loss in weight gain after the twentieth day when the rats were weaned.

The effect of small repeated doses of an alpha emitting substance have a quantitatively observable effect on the cellular constituents of the spleen of young albino rats. This deleterious effect seems to be reversible with the return to normal by various cell constituents in accordance with their radiosensitivity. It is apparent that an attempt is being made by the animal to compensate for cellular damage throughout its body and a fraction of this compensation is observable in the spleen.

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INTRODUCTION

Relatively little experimentation has been done involving the study of radiation damage due to emission of radiation from an internal source. The literature shows considerable variance in the work so reported. This is to be expected however, because the number of variables are many and are difficult to control. In the study with which this paper deals, a concerted effort was made to control as many of these variables as possible.

The purpose of this study was, first, to observe the effects of small repetitive internal doses of radium chloride on the general adaptation and metabolic processes of the young albino rat; secondly, to observe the cellular changes in the spleens of these rats, due to radiation damage; thirdly, to observe the effects of the radium on the peripheral blood stream of the rats; and fourthly, to observe how much of the radium is retained in the animal at various intervals. There have been many observations concerning the cell changes in all of the hemopoietic organs but few quantitative measurements have been made of the cellular damage. There also

is a noticeable lack of normal quantitative measurements of hemopoietic activity in the literature, especially for young animals.

Radium chloride is an alpha emitter and has a penetration range of 25 microns, therefore the area subjected to radiation can be limited to the tissues composing and adjacent (25m) to the alimentary tract and blood stream, since the radium salt was administered orally. Most of the damage done by alpha particle emission occurred within the first few hours when the radium remained in the circulating blood stream; however the half life of radium is 1,750 years, thus the fixed radium will continue to emit alpha particles for some time (Martland, 1929). The alpha particles from radium are ejected with an initial velocity of 1/20 to 1/12 that of light. If a nucleus of a lighter atom is struck squarely a high velocity hydrogen atom may be given off. This in turn strikes another atom. Such activity is a possible mechanism of action of the destructive force of an alpha emitter (Martland, 1929).

An instance was observed in which several radium dial painters became ill and died, presumably from radium ingested when they pointed the tips of their brushes with their tongues. The insoluble sulphates of the radium were fixed in the colloids and deposited in the reticulo-endothelial system of the bone marrow, spleen and liver (Martland, 1929). Thomas and Brunner (1933), after Barker, suggests that radium, in the animal system, may follow the course of calcium. Oral administration of radium sulphate showed a decrease in the mature lymphocytes in the spleen and replacement by stem cells which subsequently degenerated. The sinuses were wide and empty and a myeloid metaplasia was evident (Rosenthal, Maurice, and Grace, 1936). Elimination of the radium in the first three or four days takes place mainly through the feces (Seil, Viol, and Gordon, 1915). However, approximately thirty percent of the administered radium is retained in the bone matrix (Hoecker and Roofe, 1949). As long as there is radium in the system of the animal, some radium and radon will be in the blood and thus the blood cells are constantly being bombarded by alpha particles. Human beings receiving as much as 890 micrograms or more of radium, showed a significant retention of radium after two years but dosages below this amount showed no retention or only traces (Barker and Schlundt, 1930).

This problem arose out of an interest in the possibility of transmission of radium through the mammary gland of the female rat. We observed that by allowing the young to nurse after the $RaCl_2$

injection of the mother, repeated low dosages of radium could be be given internally to the young in this manner. Thus both immediate and long range effects could be observed without subjecting the young rats to excessive handling.

METHODS AND MATERIALS

The animals used were female Sprague-Dawley albino rats. The rats were pregnant when received and bore their litters several days after arrival. Twenty rats were used, ten of which were control and ten of which were experimental. Upon birth of the litter all but six young were removed. On the second and third day after the birth of a litter in the experimental group, 15 micrograms * of radium chloride was injected intraperitoneally into the adult female so that each adult female of this group received a total of 30 micrograms. Likewise on the second and third day after the birth of a litter in the control group, the adult female received 1.5cc of physiological saline (.9%) intraperitoneally. The young were allowed to nurse at will and a minimum of handling was involved. All litters were weaned on the twentieth day after birth. On the fourth, eighth, twelfth, sixteenth, twentieth, twenty-fourth, thirty-first, thirty-eighth, forty-fifth,** and fifty-second day after birth, one of the adult females and her litter were sacrificed, both in the control and experimental groups. The adult female was sacrificed by striking her at the base of the skull with a blunt instrument. The young were sacrificed by using ether. Latta and Ehlers (1931) report that ether anesthesia produced no changes in rats outside physiological limits. Before the animals were sacrificed each one was weighed and counts were made on the peripheral blood. Also an attempt was made to obtain blood directly from the heart by puncturing through the thorax with a needle. After the preliminary tests were made by standard laboratory procedures and the animal was sacrificed, the spleens were rapidly removed and placed in zenker-formol fixative, embedded in paraffin and sectioned at eight microns. The sections were stained with hematoxylin-eosin stain and hematoxylin-eosin-azure stain. After removal of the hemopoietic tissues from the animal, it was sealed in a jar for thirty days to allow the radium-radon equilibrium to be established (Cameron and Viol, 1915). Each litter was sealed separately in order to measure radium retention. The radiation counts were made with a "64-Scaler" using standard procedure.

* Due to some absorption of the radium on the side of the vial, exactly 15 micrograms was not given but an approximate thereof.

** The 45-day experimental animals were sacrificed on the forty-second day because it was becoming obvious that they would not live until the forty-fifth day. Thus it was of particular interest that they be used in the study.

Two animals were picked at random from the litter of six and differential cell counts of the spleen were made using a modified Chalkley (1942) procedure. Five hundred cells were counted in each tissue and the results of these counts were converted to percentage. Oil immersion was used for the cell counts with a magnification of 950 diameters. The counts were made without regard to the type of field since in most of the experimental group no distinction could be made between red pulp and white pulp. Not all of the intermediate cell types could be definitely distinguished, consequently several larger categories were counted which included intermediate cell stages. The following is a brief description of each category:

(1) *Reticular Cell*—Is an elongated cell (8 to 14 microns) with a very clear cytoplasm. The nucleus is practically indistinguishable except in outline. The width of the cell ranges from four to eight microns.

(2) *Macrophage*—Is a cell of the size of a large lymphocyte, however it contains fragments of eosinophilic staining debris. Any chromatin, if present, is also fragmented. The cytoplasm stains a light blue.

(3) *Neutrophilic Myelocyte*—Like the eosinophile myelocyte, the neutrophile myelocyte category includes slight variations just before or after the myelocyte stage. The cell contains neutrophilic staining (wine colored) granules. The nucleus is large and undivided. The cell ranges from 10 to 14 microns in diameter.

(4) *Eosinophile Myelocyte*—All cells of the granulocyte series were immature. Consequently the cells in this category include slight variations just before and after the myelocyte stage. The cell contains large eosinophilic staining granules. The nucleus is large and undivided. The cell ranges from 10 to 14 microns in diameter.

(5) *Large Lymphocyte*—Contains a dark staining nucleus which generally fills most of the cell. Frequently the chromatin was in the process of fragmentation. The cytoplasm stains a light blue. The cell ranges from 10 to 12 microns in diameter. Earlier members of the lymphocytic series could not be definitely determined so they were included in the category of large lymphocytes.

(6) *Small Lymphocyte*—Contains a small dark staining nucleus which completely fills the cell. The cell ranges from six to eight microns in diameter.

(7) *Megakaryocyte*—Is a very large cell containing a polymorphous nucleus. It usually stains lightly and has irregular shapes. The cell ranges from 40 to 120 microns in diameter.

Plasma cells, monocytes, hemocytoblasts, and basophiles were found in such low frequency that they were considered insignificant, consequently they were not included in the results. The erythroid series is explained later in the paper.

RESULTS AND DISCUSSION

The general gross appearance of the spleens from the control and experimental groups did not differ markedly. This is to be expected since the dosage received by the young animals was less than the

lethal range. Dunlop (1942) and Kolodny, (1925) report that the spleen undergoes brief early swelling and then shrinks rapidly. In some cases the spleen enlarged after massive exposure, according to (Thomas and Brunner, 1933). The younger experimental animals showed a definite contrast to the controls of the same period. They exhibited no nodules or a few with light staining cells. There was an obvious increase in eosinophile myelocytes in the experimental group which were found in clusters. Only a few were seen in the controls. The megakaryocytes were apparently increased in number in the experimental group and they were seen more frequently toward the pheriphery of the organ. The actual cell counts show a much greater contrast in cell types than is apparent upon inspection at low power under the microscope.

The following are the results and a discussion of a comparative study of the various cell types.

RETICULO-ENDOTHELIAL CELLS

The reticulo-endothelial cells include those which are phagocytic in nature. These are reticular cells and macrophages.

Reticular Cells—Because the reticular cells stain lightly they are frequently unobserved and are covered by fragments of red cells and macrophages. The experimental group showed a slight increase in reticular cells as compared to the control group (see Graph V). They were generally seen grouped together forming a reticular framework for the organ. In some cases they were seen to be part of epithelioid islands as described by (Bloom, 1948). These "free" reticular cells apparently possessed the property of being able to phagocytose debris. The "fixed" reticular cells became more condensed in the experimental group, which is similar to the work reported by (Brown, 1954). Hsii and Ma (1940) observed these phagocytes being transformed into erythrocytes, however no such transformation was seen here.

Macrophages—The macrophages were seen very soon to invade the splenic nodules of the experimental animal and were observed in abundance from the fourth day to completion of the experiment. In the control group the percent of macrophages was highly erratic, varying from 32% in the four-day animals to 71.8% in the 52-day animals. This is possibly a reflection of the cell maturation process, inasmuch as there was a corresponding decrease in lymphocytes. The experimental group also showed erratic variation but was generally higher than the control (see Graph XIII). The 42-

day animals, in particular, showed a high macrophage count, which is particularly interesting since these animals had to be sacrificed three days earlier than planned because they were obviously not going to survive. The macrophages contained nuclear and cellular debris, a great deal of which appeared to be remnants of erythrocytes. The macrophages composed the greater part of the epithelioid islands mentioned above and seemed to be most prevalent when the animal was having its most severe reaction to the radiation. The 52-day animals showed some return of the normal constituents of the splenic nodules and a reduction in the number of macrophages. As can be seen by the accompanying graphs (see Graph X and XI), the number of macrophages varies inversely with the number of large lymphocytes and this inverse ratio between the two is almost constant. It is reasonable to assume from this that the latter is the precursor of the former. Thomas and Brunner (1933) report gross loss of Malpighian corpuscles and microscopically a great decrease in the prominence of these structures. Rosenthal (1936) describes the increase in macrophages as a hyperplasia of the stem cells. Latta and Ehlers (1931) report an increase in macrophages which are laden with pigment. Bloom (1948) however, declares no reticulo-endothelial hyperplasia. Thus it is seen that there is certainly no agreement on how the debris is phagocytized or how these reticulo-endothelial cells are formed. This investigation tends to affirm that lymphocytes are precursors of macrophages.

Myeloid Cells

Erythroid cells, neutrophiles, eosinophiles and basophiles are considered in this section. In the normal spleen these cells are found in the red pulp but in the irradiated animals their location was inconstant.

Erythroid Cells—Comparative counts of the erythroid series were not attempted here since the animals were subjected to trauma just previous to being sacrificed in an attempt to obtain heart blood directly for a comparative study with the peripheral blood. Such trauma would cause a dilatation and contraction of the splenic sinuses and thus render a count of the erythroid series inaccurate. This hypothesis was verified upon low power inspection of many of the slides.

Neutrophiles—In both the neutrophile and eosinophile series, only the myelocyte stage was observed. In no instance was a mature granulocyte seen. Whether these cells mature to the

myelocyte stage and then defer their further maturation until they get into the circulation is an item for speculation but one about which no conclusive statements can be made here. In the adult albino rat there is no myelopoiesis in the spleen and the small amount seen here in the control group is attributed to the fact that these are young developing rats. Both the neutrophiles and eosinophiles approach zero toward the fifty-second day. The neutrophile myelocytes in the experimental group follow the control group very closely until the twenty-fourth day, at which time they remain somewhat elevated above the control group. On the twentieth day the animals were weaned and thus the source of radiation from the mothers milk was terminated. Thus the experimental group is shown in Graph VII dropping below the control about four days after weaning. As will be seen below however, this same thing was not manifested by the eosinophiles. Nevertheless the experimental group does show an increase in neutrophilic myelocytes. Thomas and Brunner (1933), (Latta and Ehlers, 1931) and (Rosenthal, 1936) report extra-medullary myelopoiesis in the spleen. Bloom (1948) and (Sabin and Doan, 1932), however, report comparatively little increase in ectopic myelopoiesis.

Eosinophiles—The eosinophile myelocytes of the experimental animals were consistently more numerous than those of the control animals (see Graph VIII). They were also many times more numerous than the neutrophile myelocytes. They were found in clusters in almost all cases. The 52-day experimental group showed a sharp rise in eosinophile myelocytes. Minot and Spurling (1924) reported an increase in eosinophiles after repeated short treatments with X-rays.

Basophiles—The basophiles were in such low incidence that it was thought that no significant data would be reflected in a comparative count.

LYMPHOID CELLS

Lymphoid cells include large, medium and small lymphocytes, along with monocytes which have a dubious origin but which are placed in this category arbitrarily. The large and medium lymphocytes have been grouped under one heading.

Large Lymphocytes—These cells, as was mentioned previously, varied in an inverse proportion with the macrophages. Like the macrophages, their percentage of frequency was highly erratic both in the experimental and control group. Their incidence was generally lower in the experimental group than in the control

group, and especially, the 42-day experimental animals showed a very low percentage of lymphocytes (see Graph XII). The lymphocytes of the control group were concentrated in the center of the splenic nodules but those of the experimental group showed no specific location. In the 52-day experimental animals some return of the lymphocytes to the splenic nodules was observed. In the experimental group many of the lymphocytes exhibited a pycnotic nucleus and many were in the process of shattering. Bloom (1948) and (Thomas, 1933) reported similar results. The latter also reported immature lymphocytes present in greater numbers than normal.

Spurling and Lawrence (1925) have shown that leucocytes are not affected directly, in the blood stream, within an hour and a quarter after irradiation, but most of the degenerated forms are due to an indirect effect.

Small Lymphocytes—The number of small lymphocytes did not change significantly in either the control or the experimental group, except in the very young animals (see Graph VI). They were, in fact, relatively infrequent. Warren, MacMillan and Dixon (1950) using a beta emitter on mice, report a decrease in the number of small lymphocytes.

Monocytes—It was considered impractical to attempt to distinguish between large lymphocytes and monocytes, so a discussion of this group will not be included in this paper.

Other Cell Types

Megakaryocytes—The number of megakaryocytes in the experimental group from the eighth day to sacrifice were quite significantly higher than those of the control group. The control group by the thirty-eighth day showed practically no incidence, while the experimental group showed a variable but high incidence of megakaryocytes (see Graph IX). Bloom (1948) reports degeneration and disappearance of the megakaryocytes. Thomas and Brunner (1933) report an increase in megakaryocytes, in some cases, being very numerous.

Kolodny (1925) after experimental deep roentgen irradiation, found an increase in blood coagulability and postulated that due to destruction of splenic follicles, thrombokinetic and thromboplastic substances were released. While attempting to get peripheral blood from the tail of the rats in our experimental group, an increase in coagulability was also noticed. Since the theory for origin of platelets has found considerable proof recently (Russell

and Roofe, 1954) the increase in megakaryocytes could account for this increase in coagulability; however, most of the platelets are furnished by the megakaryocytes of the bone marrow. The platelet count is extremely variable and does not correspond to the changes in megakaryocytes in the spleen. Dunlop (1942) reported a shortening of coagulation time but does not attempt an explanation.

Plasma Cells—Thomas and Brunner (1933) found many lymphocytes converted to plasma cells, which are common reactive cells in certain chronic diseases. None were found however in either the control or experimental groups here.

PERIPHERAL BLOOD

A study of the peripheral blood was made on each animal before it was sacrificed. This study includes a white cell count, red cell count, platelet count and a differential count.

White Blood Cell Count—The white cell count of the control and experimental group remained approximately the same until the twelfth day, at which time the experimental group showed a definite decrease in white cells, (see Graph I). The decrement becomes greater toward termination of the study. This decrease does not correlate with the white cells in the spleen. Dunlop (1942) after Liechti, reported an incomplete summation of divided doses, and less blood damage resulting than if a total dose had been given at a single time (after Gloor and Suppinger). He also states that young subjects are more susceptible to radiation than normal adults (after Heim and Steton). From this we can assume that the summation of dosages tends to produce less effect than had the dose been given at a single time; however, due to the youth of the animals more peripheral blood damage should be apparent than an adult would show. Murphy and Nakahara (1920) report small doses of X-rays stimulate lymphocyte production. However, (Mottram and Russ, 1921) claim that this lymphocytosis was a compensatory reaction due to an initial lymphopenia immediately following irradiation. Lawrence (1948) reports direct irradiation of hemopietic tissue produces a leukopenia but radiation in other parts of the body does not have a similar effect. Hsii and Ma (1940) report lymphopenia and polymorphonuclear leukopenia as constant findings.

In normal adult albino rats, Downey (1938) reports an average leucocyte count of 11,000 with a range from 5,800 to 29,800. The normal animals in our work from four to fifty-two days in age, showed a range in leucocyte count of 2,025 to 25,650 (see table I).

The leucocyte count started low (4,400) in the four-day animals and rose steadily but showed no definite leveling off stage within the 52-day period (see Graph I).

Kindred (1937, 1940) reports most of the lymphocytes of normal young animals (15 to 20 days old) are small lymphocytes whereas the lymphocytes of older animals (80 days old) are mostly medium lymphocytes. The normal animals in our study show a very small percentage of small lymphocytes in the 15- to 20-day-old animals, with most of the lymphocytes being large ones (see table II). As the age of the animal increases this predomination of large lymphocytes remains.

Red Blood Cell Count—The red cell count in the experimental group remained approximately the same as the control group throughout (see Graph II). The experimental animals showed a slight erythropenia but followed the same contour as the control group. From this work and the observations of other workers, the theory that the erythrocytes are more resistant to radiation than the lymphocytes or granulocytes, seems to be substantiated. Hsii and Ma (1940) report the erythrocytes to be definitely affected and report an increase in erythropoiesis in the spleen. As was stated above, in the experimental group it was impossible to accurately determine the amount of erythropoiesis because of the engulfing of an abnormal number of erythrocytes by macrophages. Kolodny (1925), (Hsii and Ma, 1940) also report similar observations. Brown (1954) reports an abnormal number of normoblasts in the peripheral blood. Our control group also showed normoblasts in the peripheral blood but less abundantly than in the experimental group and they did not remain as long (see Graph IV).

Downey (1938) reports for the adult albino rat an average red cell count of 6,180,000 with a range from 5,800,000 to 11,200,000. Our control animals had a range of 2,760,000 to 9,375,000, showing a steady climb from the four-day animals to the 52-day animals (see Graph II). The red cell count showed a tendency to level off at approximately 6,000,000 by the twenty-fourth day, however later this count varied. The normoblasts of the control group were as high as 21 per 100 leucocytes but had practically disappeared by the twenty-fourth day (see Graph IV). Those of the experimental group however rose as high as 63 per 100 leucocytes and were in evidence as long as the forty-second day.

Platelet Count—The platelet count of both the control and experimental group was highly variable (see Graph III). Justifica-

tion for the variability in platelet count in these animals does not seem to be obvious. The rise and fall of platelets does not correlate with the megakaryocyte curve or the change in coagulation time.

Downey (1938) reports a range in platelets from 121,000 to 460,000 for the adult albino rat. Some give an average as high as 1,275,000 (after Downey). The range in our control animals showed a total variation from 369,000 to 1,075,000, from a four-day to a 52-day period (see Table I).

Differential Count—The differential count of the experimental group is similar to that of the control group throughout the 52-day period (see table I). The only difference seen is a slight prevalence of immature cells in the experimental group. This is possibly a reflection of the radiation damage on the centers of hemopoiesis.

BODY WEIGHT

The weight of the experimental animals held very close to the weight of the control group until the twentieth day, at which time the animals were weaned. From this time on the control animals continued to gain steadily, whereas the experimental animals remained about the same weight or gained very slightly (see Graph XV). Rosenthal (1936) reports a market loss in weight and pathological fractures. Also by oral administration of radium sulfate, gingivitis, alopecia, abrasion of teeth and necrosis of bone were demonstrated by Rosenthal. We have similar observations, with a tendency of the bones to fracture.

RADIUM RETENTION

The percentage of radium consumed by the young rats is impossible to ascertain since the actual amount of radium being obtained through the milk of the mother is unknown and the frequency which they nursed was uncontrollable. The number of micrograms retained by the whole litter of six was measured however. The amount of radium retained by the litter decreases steadily from the eight-day animals to the 52-day animals, with two notable exceptions (see Graph XIV). The explanation for these inconsistencies is unknown. Seil, Viol and Gordon (1915) report that 60% to 98% of the radium taken into the human system is eliminated principally in the feces (90%) and urine (10%). When taken by mouth 65% to 75% is eliminated in the first four days and by the tenth day the daily elimination rate is less than 1%. Thereafter there is a gradual diminution in its removal so that after several years the

rate of elimination is .002% to .005% per day. Since the mothers of our animals were given approximately 30 micrograms intraperitoneally and the young were receiving their source of internal radiation from the milk of the mother, it is seen that a number of possible exits for the radium is available. Yet the retention data of the young animals shows a total variation of 5.4 micrograms to 12.8 micrograms retained by the litter (see Graph XIV). Thus the litter retained from 1/6 to more than 1/3 of the total amount of radium chloride received by the mother, showing that a relatively high percentage of the total amount of radium chloride injected was passing thru the milk to the young. Hoecker and Roofe (1949) report a retention of about 30% in the animal and most of this is retained in the bone ash; however the radium is eliminated from the blood stream in a very few minutes. The above data reported by Seil, Viol and Gordon did not include data on lactating females. Seil, Viol and Gordon (1915), after Ketron and Bellingham-Smith, report practically no radium being eliminated through the skin, which is contradictory to the results of our study if the mammary gland is considered a modified sebaceus gland. A number of methods have been attempted to increase the rate of excretion of radium with some success (Thomas and Brunner, 1933) but all seem to have unwanted side reactions.

Summary and Conclusion

Adult female albino rats were injected intraperitoneally with approximately 30 micrograms of radium chloride. The females and their litters were sacrificed at specific time intervals from 4 to 52 days after birth. The spleens of the litter animals were examined quantitatively on the basis of percentage composition for comparison of constituent cells. A study of the peripheral blood was also made just preceding death. The results of these studies have been stated and shown graphically. The following are the most striking results:

1. The consumption of radium chloride through the milk of the mother by the young rats causes changes in the splenic tissue of the rats. These include loss of condensed splenic nodules, and a displacement of cell function and nuclear organization.
2. The alpha irradiation from radium chloride caused considerable disturbance in the relative quantities of the cellular constituents of the spleen. These changes include:
   (*a*) An increase in the number of macrophages and an invasion by these macrophages into the former splenic nodules;
   (*b*) A breakdown and destruction of erythrocytes which in turn were phagocytized by the reticulo-endothelial cells;

(*c*) An increase in the amount of granulocytic myelopoiesis with a particular increase in eosinophile myelocytes;

(*d*) A decrease in the number of lymphocytes present, varies inversely with the number of macrophages present;

(*e*) An increase in the number of megakaryocytes with heavy concentration around the periphery of the organ.

3. The alpha radiation from radium chloride caused peripheral blood damage which includes:

(*a*) A lowering of the white blood count below that of "normal."

(*b*) An increase in the number of normoblasts present in the peripheral blood.

4. The effect of the radiation on the weight of the animals was dramatic, showing a distinct loss in weight gain after the twentieth day when the rats were weaned.

The effect of small repeated doses of an alpha emitting substance have a quantitatively observable effect on the cellular constituents of the spleen of young albino rats. This deleterious effect seems to be reversible with the return to normal by various cell constituents in accordance with their radiosensitivity. It is apparent that an attempt is being made by the animal to compensate for cellular damage throughout its body and a fraction of this compensation is observable in the spleen.

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TABLES AND GRAPHS

TABLE I

PERIPHERAL BLOOD DATA

Explanation:

The column headed "Date" refers to the number of days between birth of the litter and the time of sacrifice.

The column headed "Type" gives reference to either experimental or control animals.

The succeeding columns are self explanatory and give both the average and the range. The range is the actual raw data of the two animals used in each age group. The red counts, white counts and platelet counts are based on cells per mm^3. The differential and normoblast counts are based on 100 counted leukocytes.

Those spaces which are blank under "range" indicate that there was no range, either due to inability to get the count, or due to the absence of that cell type.

Those which are blank under "average" indicate that it was impossible to get a count.

The weights of the 45- and 52-day control animals were not taken.

* The 45-day experimental animals were sacrificed on the forty-second day because it was becoming obvious that they would not live until the forty-fifth day.

TABLE I

Date	Type	Weight in grams		Normoblasts per 100 leuk		Platelets		White count		Red count		Differential count	
		Av.	Range	Av.	Range	Av.	Range	Av.	Range	Av.	Range	Average	Range
4 day	Cont.	8.5	8.4- 8.6	16	.....	378,000	.....	4,400	3,600- 5,200	2,760,000	.....	lym 63, poly 36, eos 1	.....
	exp.	7.6	6.7- 8.5	63	32-94	285,000	226,000-344,000	6,825	2,950- 9,700	2,600,000	2,530,000-2,670,000	lym 58, poly 40, mono 2	lym 50-66, poly 30-50, mono 0-2
8 day	cont.	15.2	13.5-16.9	21	17-25	369,000	368,000-370,000	2,025	1,350- 2,700	3,400,000	3,230,000-3,570,000	lym 76, poly 22, erythro bl. 1, mono 1	lym 73-80, poly 20-25, eos 1, erythro bl. 1
	exp.	12.8	11 -14.7	27	20-35	462,000	426,000-498,000	2,500	2,350- 2,650	3,095,000	3,040,000-3,150,000	lym 74, poly 24, erythro bl. 1, mono 1	lym 74-75, poly 24-25, erythro bl. 1 mono 1
12 day	cont.	16.7	14.9-19	10	.....	638,000	.....	5,050	.....	4,800,000	.....	lym 73, poly 25, mono 2	.....
	exp.	25.75	25.7-25.8	9	8-10	476,000	472,000-480,000	4,625	4,000- 5,250	3,290,000	3,220,000-3,350,000	lym 81, poly 12, meta 5, mono 2	lym 79-83, poly 12-13, meta 3-7, mono 1-2
16 day	cont.	36.0	33.9-38.2	1	.....	587,000	580,000-595,000	7,575	7,550 - 7,600	4,460,000	4,080,000-4,860,000	lym 77, poly 22, eos 1, baso 1, mono 1	lym 72-82, poly 17-26, eos 1, mono 1, baso 1
	exp.	31.8	31.6-32.1	5	4- 6	594,000	588,000-700,000	5,475	5,050- 6,000	3,510,000	3,460,000-3,560,000	lym 74, poly 21, eos 1, meta 1, erythro bl. 1, mono 1	lym 73-75, poly 19-23, eos 1-2, meta 1, erythro bl. 1, mono 1, target cell 1
20 day	cont.	45.3	44.5-46.1	.....	.....	468,000	432,000-504,000	9,200	6,600-11,900	5,645,000	5,550,000-5,740,000	lym 85, poly 15	lym 80-90, poly 10-20
	exp.	42.2	41.3-43.2	1	0- 2	797,000	595,000-1,000,000	5,625	5,000-66,250	3,840,000	3,560,000-4,120,000	lym 87, poly 12, meta 1	lym 81-89, poly 10-15, meta 1

TABLE I.—Concluded

Date	Type	Weight in grams		Normoblasts per 100 leuk		Platelets		White count		Red count		Differential count	
		Av.	Range	Av.	Range	Av.	Range	Av.	Range	Av.	Range	Average	Range
24 day	cont.	58.5	58.4-58.7	3.5	3- 4	521,000	516,000-526,000	7,725	7,500- 7,950	6,280,000	6,130,000-6,430,000	lym 83, poly 16, eos 1	lym 83-84, poly 16, eos 1
	exp.	38.5	38.4-38.7	4	3- 5	420,000	308,000-532,000	6,300	5,950- 8,650	6,090,000	6,050,000-6,130,000	lym 82, poly 14, meta 3, mono 1	lym 81-83, poly 12-16, meta 34, mono 1
31 day	cont.	79.8	78.4-81.3	1	.....	467,000	452,000-482,000	11,225	9,800-12,650	6,230,000	6,120,000-6,340,000	lym 82, poly 17, eos 1	lym 79-85, poly 14-20, eos 1
	exp.	49.8	46.5-34.2	.....	.....	705,000	690,000-720,000	5,650	5,280- 5,850	5,810,000	5,800,000-5,820,000	lym 91, poly 8, meta 1	lym 91, poly 8-9, meta 1
38 day	cont.	104.8	103.6-106	.....	.....	348,000	334,000-362,000	12,075	12,050-12,100	5,285,000	4,410,000-5,960,000	lym 89, poly 8, eos 1, mono 1, myelo 1	lym 88-91, poly 8-10, myelo 1, eos 1, mono 1
	exp.	43.5	43 -44.1	.....	.....	407,000	344,000-470,000	4,450	4,200-4,700	4,345,000	4,010,000-4,680,000	lym 81, poly 19	lym 80-82, poly 18-20
45 day	cont.	.....	.....	.....	.....	1,080,000	1,050,000-1,110,000	26,650	22,250-29,050	6,815,000	5,860,000-7,770,000	lym 80, poly 19, eos 1	lym 74-86, poly 14-25, eos 1
	exp.	36.1	34.2-38	11	7-15	413,000	404,000-422,000	5,160	3,600- 4,720	6,985,000	6,360,000-7,610,000	lym 48, poly 50, eos 1, mono 1	lym 48-50, poly 48-50, eos 1, mono 1
52 day	cont.	.....	.....	.....	.....	835,000	780,000-990,000	19,450	14,700-24,200	9,375,000	8,650,000-10,100,000	lym 82-89, poly 10-17, eos 1	lym 82-89, poly 10-17, eos 1
	exp.	53.8	46.8-60.8	.....	.....	358.000	326,000-390,000	8,950	6,100-11,150	7,085,000	7,010,000-7,160,000	lym 74, poly 23, eos 2, mono 1	lym 73-75, poly 23, eos 1-4, mono 1

TABLE II

Spleen Differential Count

Explanation:

The column headed "Date" refers to the number of days between birth of the litter and the time of sacrifice.

The column headed "Type" gives reference to either experimental or control animals.

The succeeding columns are self explanatory and give both average and range, which is actually the raw data of the two animals used in each stage. All figures represent percentage. Those spaces which are blank under "range" indicate that there was no range, either due to inability to get the count, or due to absence of that cell type.

* The 45-day experimental animals were sacrificed on the forty-second day because it was becoming obvious that they would not live until the forty-fifth day.

TABLE II

DATE	Type	Small lymphos		Large lymphos		Reticular cells		Macrophages		Eos. myelo.		Neut. myelo.		Megakaryo	
		Av.	Range	Av.	Range	Av.	Range	Av.	Range	Av.	Range	Av.	Range	Av.	Range
4 day	cont.	.5	.2- .8	65.3	64.4-66.2	.5	.2- .8	32.7	32 -33.4	.8	.....	.7	.6- .8	1.1	1.0-1.2
	exp.	5.4	0 -10.9	28.9	25.8-34	0	.....	66.4	56.6-76.2	1.6	0 - 3.3	.5	0 -1.0	.8	.4-1.2
8 day	cont.	.4	.....	34.8	29.8-39.8	1.3	1.0- 1.6	59.7	53.8-65.6	1.6	1.0- 2.2	.4	.2- .6	2.2	.....
	exp.	1.3	0 - 2.6	40.0	31.2-48.8	0	.....	56.0	48.4-63.3	1.6	1.0- 2.2	.5	0 -1.0	1.9	1.0-2.8
12 day	cont.	.8	.4- 1.2	23.6	23.4-23.8	2.0	1.0- 3.0	68.6	67.6-69.6	1.8	1.6- 2.0	1.1	.6-1.6	1.1	.8-1.4
	exp.	4.4	4 - 4.8	19.6	18.8-20.4	8.7	5.6-11.8	59.0	61 -57	4.7	4.6- 4.8	1.4	1.2-1.6	5.9	4.4-7.4
16 day	cont.	0	.....	43.4	35.8-51.0	0	.....	51.9	44 -59.8	2.2	1.8- 2.6	1.0	.8-1.2	1.6	.....
	exp.	.1	0 - .2	32.9	31.4-34.4	1.3	.6- 2.0	53.6	50 -57.2	6.0	5.0- 7.0	.9	.6-1.2	5.1	4.8-5.4
20 day	cont.	.6	.4- .8	44.5	42.6-46.4	.3	.2- .4	48.8	46 -51.6	2.5	2.4- 2.6	1.5	1.4-1.6	1.5	1.2-1.8
	exp.	0	.....	36.6	34.6-38.6	.2	0 - .4	52.4	51 -53.8	6.7	6.2- 7.2	1.5	.8-2.2	3.1	2.0-4.2
24 day	cont.	1.5	.4- 2.6	57.4	56.2-58.6	.4	.....	36.6	36 -37.2	2.7	2.6- 2.8	.2	.....	1.2	.8-1.6
	exp.	.1	0 - .2	40.6	33.2-48	1.7	.6- 2.8	50.5	43.2-57.8	4.4	4.0- 4.8	.2	0 - .4	2.8	2.4-3.2
31 day	cont.	.1	0 - .2	40.9	33.6-48.2	.1	0 - .2	56.8	50.4-63.2	1.1	.4- 1.8	0	.....	.9	.6-1.2
	exp.	1.0	0 - 2.0	36.6	35.8-37.4	.5	.4- .6	55.5	53.2-57.8	3.3	2.8- 3.8	.3	.2- .4	3.4	3.0-3.8
38 day	cont.	0	.....	64.9	60.2-69.6	.1	0 - .2	34.8	30 -39.6	0	.....	0	.....	.1	0 - .2
	exp.	0	.....	18.5	18.2-18.8	0	.....	78.6	77.4-79.8	1.9	1.8- 2.0	1.0	.8-1.2	.8	.2-1.4
45 day	cont.	0	.....	31.2	29 -33.4	0	.....	68.4	66.4-70.4	.4	.2- .6	0	.....	0	.....
	exp.	0	.....	8.9	5.2-12.6	1.2	.4- 2.0	87.1	82.6-91.6	2.0	.....	.3	.2- .4	.7	.6- .8
52 day	cont.	0	.....	25.8	24.2-27.4	1.2	.2- 2.2	72.4	71.8-73	.3	.2- .4	.1	0 - .2	.1	0 - .2
	exp.	0	.....	24.7	23.8-25.6	.9	.4- 1.4	62.3	62 -62.6	9.6	7.6-11.6	.8	.6-1.0	2.6	2.2-3.0

GRAPH I

Peripheral Blood

White Cell Count

Explanation:

"Days" refers to the number of days after birth of the litter.

The ordinate represents the leukocytes in thousand per mm^3.

The solid line represents the control group and the broken line represents the experimental group.

GRAPH II

Peripheral Blood

Red Cell Count

Explanation:

"Days" refers to the number of days after birth of the litter.

The ordinate represents the erythrocytes in million per mm^3.

The solid line represents the control group and the broken line the experimental group.

GRAPH III

Peripheral Blood

Platelet Count

Explanation:

"Days" refers to the number of days after birth of the litter.

The ordinate represents the platelets in hundred-thousand per mm^3.

The solid line represents the control group and the broken line the experimental group.

GRAPH IV

Peripheral Blood

Normoblasts

Explanation:

"Days" refers to the number of days after birth of the litter.

The ordinate represents the normoblasts per 100 leukocytes.

The solid line represents the control group and the broken line the experimental group.

GRAPH V

Spleen-Differential Count

Reticular Cells

Explanation:

"Days" refers to the number of days after birth of the litter.

The ordinate represents the percentage of reticular cells.

The solid line represents the control group and the broken line the experimental group.

GRAPH VI

SPLEEN-DIFFERENTIAL COUNT

Small Lymphocytes

Explanation:

For explanation of abscissa see above.

The ordinate represents the percentage of small lymphocytes.

The solid line represents the control group and the broken line the experimental group.

GRAPH VII

SPLEEN-DIFFERENTIAL COUNT

Neutrophile Myelocytes

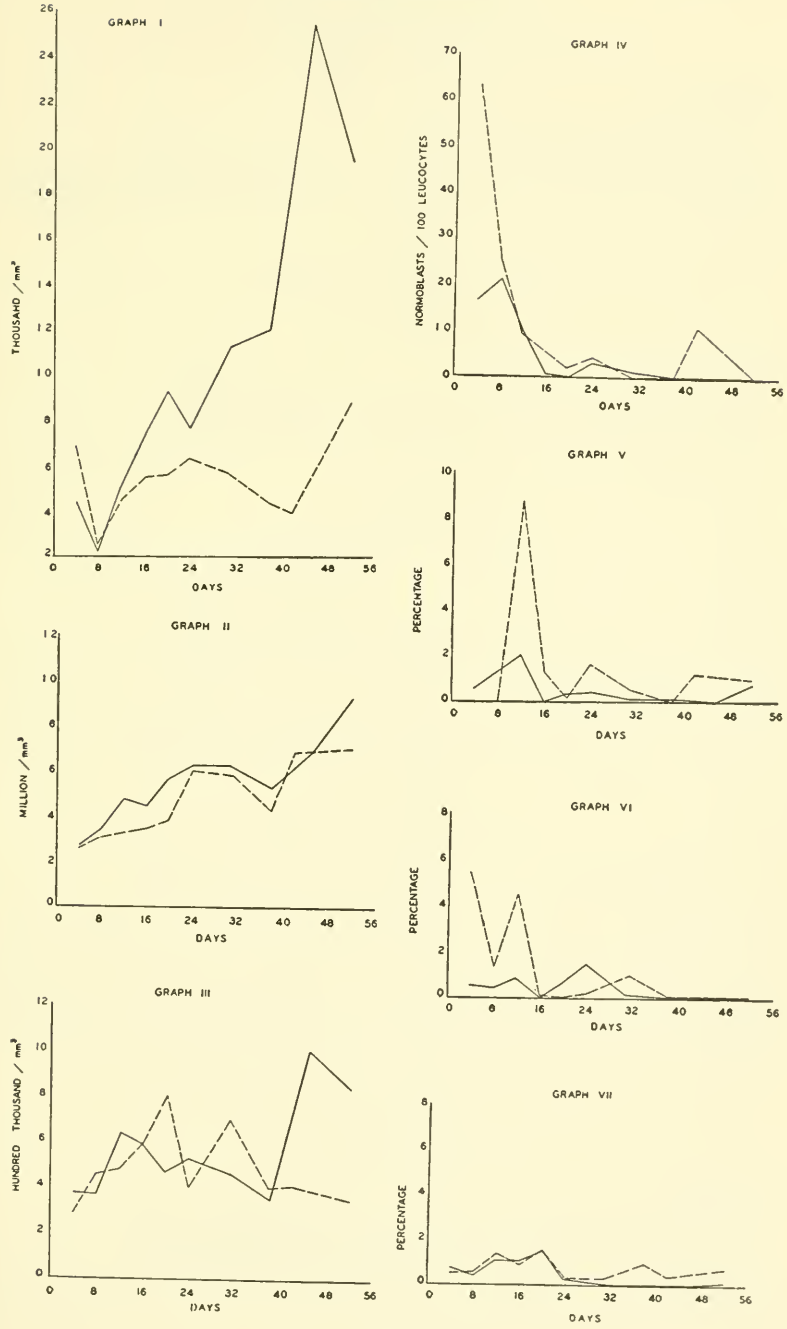
Explanation:

"Days" refers to the number of days after birth of the litter.

The ordinate represents the percentage of neutrophile myelocytes.

The solid line represents the control group and the broken line the experimental group.

GRAPHS I to VII



GRAPH VIII

SPLEEN-DIFFERENTIAL COUNT

Eosinophile Myelocytes

Explanation:

For explanation of abscissa see above.

The ordinate represents the percentage of eosinophile myelocytes.

The solid line represents the control group and the broken line the experimental group.

GRAPH IX

SPLEEN-DIFFERENTIAL COUNT

Megakaryocytes

Explanation:

"Days" refers to the number of days after birth of the litter.

The ordinate represents the percentage of megakaryocytes.

The solid line represents the control group and the broken line the experimental group.

GRAPH X

SPLEEN-DIFFERENTIAL COUNT

Large Lymphocytes and Macrophages (control)

Explanation:

"Days" refers to the number of days after birth of the litter.

The ordinate represents the percentage of large lymphocytes and macrophages.

The solid line represents the macrophages of the control group and the broken line represents the large lymphocytes of the control group.

GRAPH XI

SPLEEN-DIFFERENTIAL COUNT

Large Lymphocytes and Macrophages (experimental)

Explanation:

"Days" refers to the number of days after the birth of the litter.

The ordinate represents the percentage of large lymphocytes and macropages.

The solid line represents the macrophages of the experimental group and the broken line represents the large lymphocytes of the experimental group.

GRAPH XII

SPLEEN-DIFFERENTIAL COUNT

Large Lymphocytes

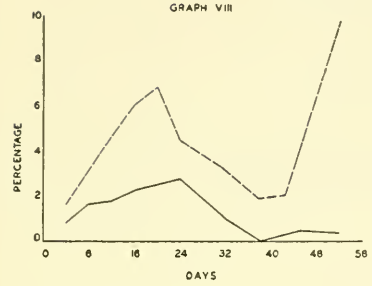
Explanation:

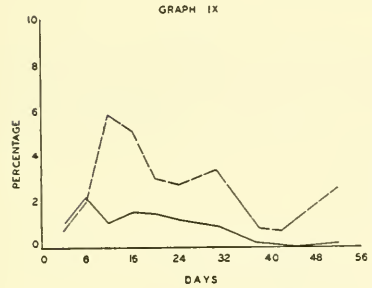
"Days" refers to the number of days after the birth of the litter.

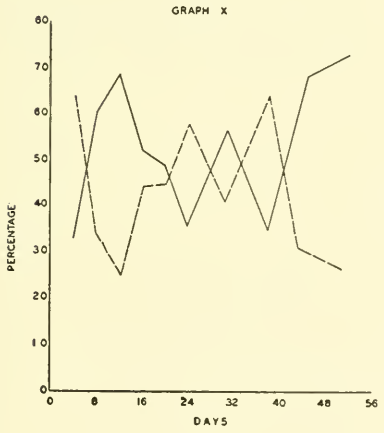
The ordinate represents the percentage of large lymphocytes.

The solid line represents the control group and the broken line the experimental group.

GRAPHS VIII to XII







GRAPH XIII

SPLEEN-DIFFERENTIAL COUNT

Macrophages

Explanation:

"Days" refers to the number of days after the birth of the litter.

The ordinate represents the percentage of macrophages.

The solid line represents the control group and the broken line the experimental group.

GRAPH XIV

RADIUM RETENTION

Explanation:

"Days" refers to the number of days after birth of the litter.

The ordinate represents the number of micrograms of radium retained. The great deviations in the general trend of the curve is unexplainable. There is a possibility that there was a leak in the jars in which the animals were sealed.

GRAPH XV

BODY WEIGHT

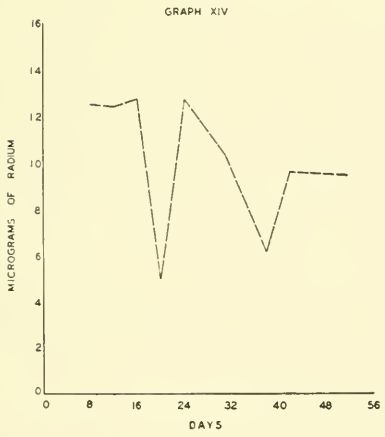
Explanation:

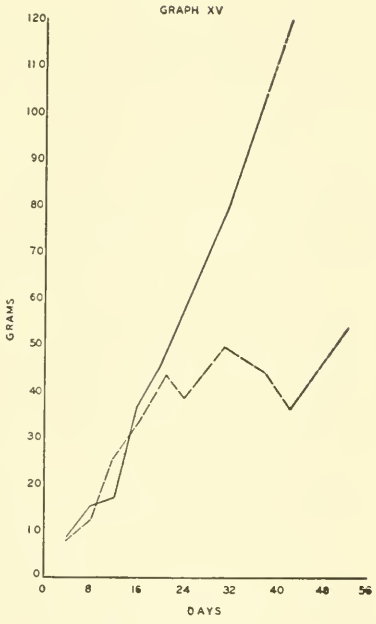
"Days" refers to the number of days after birth of the litter.

The ordinate represents the weight of the animals in grams.

The solid line represents the control group and the broken line represents the experimental group. The line represented by long and short dashes indicates the probable trend of the 45- and 52-day control animals, since that data was not obtained.

GRAPHS XIII to XV





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A Study of the Effects of Protein Fast and Internal Irradiation on the Bone Marrow of the Male Albino Rat [1]

BY

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ABSTRACT: Two groups of experimental animals were used in this experiment. The animals in the first group were subjected to protein fast and the animals in the second group were injected intraperitoneally with radium chloride. Differential counts were made by a random selection procedure on the bone marrow taken from these animals. Toluidine blue was used as the stain to determine the effect the protein fast and irradiation had on the nucleic acid content of the tissue.

1. Cellular basophilia and nucleic acid content is not noticeably affected by protein fast and radiation under the conditions described in this experiment.

2. Total bone marrow basophilia and nucleic acid content is reduced during protein fast due chiefly to reduction in cellularity.

3. Fatty displacement of tissue occurs in bone marrow during protein fast.

4. Mitotic activity is decreased by both protein fast and radiation.

5. Changes which take place in the bone marrow during protein fast are overcome when animals are returned to normal protein diets.

6. The myeloid/erythroid ratio increases during protein fast and following irradiation.

7. In the bone marrow erythropoietic elements are the most easily affected by protein fast and internal irradiation, and granulocytopoietic elements are more susceptible than are the megakaryocytes.

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INTRODUCTION

It is well known that protein is one of the most important dietary constituents, and that adequate amounts of protein are essential for normal nutrition and body metabolism (Orten and Orten, 1943; Wright, 1946). It is also an accepted fact that the protein supplied in the diet must contain suitable quantities of the essential amino acids to meet the body needs for protein biosynthesis (Benditt, 1947). Recently experimental evidence has shown that the nucleic acids play an important role in protein synthesis, but the exact nature of the nucleic acid action is still unknown. In a review, Caspersson (1947) has suggested that the nucleic acids are essential for such self-reproducing units as the gene, and that they are abundant in cells in which rapid protein synthesis is taking place either for the production of gene-proteins, or in the production of the main bulk of cytoplasmic proteins for growth or secretion.

Originally, nucleic acids were thought to be localized solely in the cell nucleus. It is now an established fact that two kinds of nucleic acids exist—ribo and desoxyribonucleic acids—and that RNA is localized in the cytoplasm with DNA localized in the cell nucleus (Davidson, 1950). The nucleic acids have been identified and localized by basic staining, enzyme digestion techniques, the Feulgen reaction, and ultraviolet absorption. Caspersson (1947) has attempted to use the latter technique as a means of quantitatively determining nucleic acid content of tissues. In a review, Roofe and Lesher (1951) have pointed out that many of the results obtained by the absorption method are quantitatively invalid, but the qualitative information is valuable.

Since the beginning of the atomic era investigators have become curious as to the effect the products of atomic fission will have on living tissue. A great deal of time and effort has been and is being devoted to determine some of the effects. This study was made to obtain more data on the histological changes in the bone marrow which occur during protein fast and after internal irradiation. A qualitative histochemical procedure was also employed to determine what effect these conditions would have upon the nucleic acid content of the bone marrow.

MATERIALS AND METHODS

Male Sprague-Dawley rats served as the experimental animals. Those rats used in the radiation experiment were mature animals while those used in the protein experiment were fifty days old when placed on their respective diets. For the duration of the

experiment all animals were confined in individual cages in a room where the temperature was maintained at approximately 70 F.

In the protein deficiency experiment the following dietary groups were formed:

Group A—Purina fox chow diet
Group B—Synthetic protein diet
Group C—Synthetic 0.0% protein diet
Group R—0.0% protein for 35 days and fox chow from days 35-56.

Animals in Group C served as experimental animals. Those in Groups A and B served as control animals, and the animals in Group R served as experimental recovery animals. The constituents of the diets for Groups B and C are shown in Table I. All animals were maintained on their respective diets until a 14-day interval had elapsed, when representatives from each group were sacrificed. Others were then sacrificed at one week intervals. Animals referred to as R (recovery) were placed on the 0.0% casein diet on the same date as those in Group C. This feeding was continued for 35 days and at that time they were placed on the Purina fox chow diet. After a two week interval, animals in Group 1R were sacrificed as were those in Group 2R the following week.

In the radiation experiment, 14 animals were used: Seven experimental and seven control. These animals were designated as Ra1-Ra7 and N1-N7 respectively. All animals were fed Purina fox chow. Group Ra animals were injected intraperitoneally with 10 micrograms of radium chloride. Geiger counts were made on these animals on the injection date and at one-week intervals for the duration of the experiment. The data obtained from these counts is shown in Graph VIII. Animal Ra1 was sacrificed seven days after the injection date and the remainder were sacrificed individually at seven-day intervals. One normal (control) animal was sacrificed with each irradiated animal.

The animals used in both parts of this experiment were killed by a blow on the head. Immediately after killing, the right femur was removed and cracked open with a pair of forceps. A sample of bone marrow throughout the shaft was then lifted out and placed into the fixative. The following tissue technique was used:

Fixation	Carnoy's	60 min.
Washing	95% alcohol	3-20 min. each
Clearing	amyl acetate	23 hours
Imbedding	50-52 C paraffin	60 min.
Sectioning		7 micra
Hydration		xylol—H_2O

Staining	toluidine blue	20 min.
Differentiation	tertiary butyl alcohol	23 hours
Dehydration		H_2O—xylol

A 1% solution of toluidine blue, a thiazine dye, was used as a tissue stain. Toluidine blue combines with basophilic substances such as half-esters of sulfuric acid with colloidal carbohydrate of high molecular weight, which may or may not be in combination with protein. The absorption of the dyestuff cation by nucleic acids takes place by means of the phosphoric acid group of the acids. It is believed that treatment of the tissues with alcohol after toluidine blue staining removes only the excess dye (Michaelis, 1948). Tertiary butyl alcohol was used in destaining, for it was found to preserve the brilliance of the dye better than ethyl alcohol.

Maximow's (1950) criteria of cell types was used for the differential counts in the experiment. All cells, both mature and immature, were classified by the term Maximow has given the adult form in their respective series. The method for counting was patterned after Chalkley's (1943) sampling method. This modification of his technique consisted of arranging four pointers in the ocular of the microscope and then identifying and counting the cell types lying under the tips of the pointers. The count was made by random selection of a number of fields and was terminated when the erythrocyte count had reached 100. By using this method, data for the differential was obtained as a ratio; for example, 60 neutrophils per 100 erythrocytes. In addition to this technique, a method for determining changes in total cell population was devised. This consisted in counting the number of cells in an area of 2,500 square microns with the aid of a camera-lucida. The average of the count made by random selection of 10 fields was used to express the trend of change in the total cell population.

RESULTS

Weight Results

The dietary and experimental conditions for the various groups have been mentioned in a previous section of this paper. The weight variation data will be found in Tables II to V. These tables give both absolute and percentage weight changes for the individual animals used.

Table II contains the weight records for those animals placed in Groups A and B. As shown, both groups of animals behaved similarly as to growth changes. Both diets seemed to satisfy the

animals. The only factor which varied with these two groups was the greater water consumption by those animals in Group A. This can be explained by the dryer consistency of their food.

Table III contains the weight data for those animals on the synthetic 0.0% protein diet. These animals showed a marked drop in weight by the fourth day of the experiment. As can be seen, the weight loss was progressive until about the thirty-fifth day of protein fast, at which time there was a leveling off. Such a trend also appeared in the cytological changes. These animals were retarded in all aspects of growth. Their bones remained small, their external genitalia did not develop, and their fur became yellow and shabby. Toward the latter part of the experiment, they became extremely nervous and would nibble on their tails. These animals consumed extremely small quantities of water and wasted much of the food placed in their cages.

Table IV contains the weight data for the recovery groups (R). These animals were maintained on the 0.0% protein diet for 35 days and then placed on the recovery Purina fox chow diet. As shown, these animals made a marked weight recovery. Their cytological recovery was also very pronounced.

Table V contains weight data for animals in the radiation experiment. The irradiated animals showed a progressive weight loss throughout the experiment, while their controls showed a slight increase in weight. Since all of the animals used were mature, no great weight changes were anticipated in the control group. No marked change in food or water consumption was noted in the irradiated group, which suggests that the radium affected the utilization of ingested food. This change was probably due to actual tissue damage of the intestine (Bloom, 1948).

Histological Results

Tables VI to VIII contain the data on the differential counts made of tissues taken from protein deficient, irradiated, and control animals. These data are presented graphically on Graphs I to VII. Ordinates of the graphs show the number of cells per 100 erythrocytes, and the abscissae show time.

From Table VI it can be seen that the animals on the synthetic protein and fox chow diet presented a very similar cytological picture. As the animals became older, the neutrophil/erythroid ratio increased slightly, and the activity of the bone marrow decreased. This decrease in activity was evidenced by the appearance of a greater number of mature cells in the tissue and by the

development of more fat vacuoles. Such a decrease in activity is noted by Maximow and Bloom (1950).

Table VII contains the data on both protein deficient and recovery animals. Group C, or protein deficient animals, show very marked changes in hemocytoblast, megakaryocyte, and neutrophil rations. The hemocytoblast level was maintained fairly well through Group 1C, but a definite change from normal occurred within the next week. This decline in numbers increased through Group 4C. The megakaryocyte picture not only shows a decisive change in Group 1C, but their numbers continue to increase on through Group 4C. The lymphocyte ratio increased slightly throughout the experiment. The neutrophil ratio also shows a marked increase, though not so dramatic as the megakaryocyte change. Another decisive change occurred in the marrow as indicated by the absolute drop in cell numbers. This change, though pronounced by two weeks on the deficient diet, was continuous throughout the series. In these latter stages of the experiment, approximately 50% of the previously active tissue had been replaced by fat.

Table VII also contains the data on differential counts taken from the bone marrow of the recovery animals. These animals are actually a continuation of Group C, as has been previously stated. This group showed remarkable recovery after being placed on a diet with adequate protein. The impetus to recovery can be recognized by the tremendous increase in the absolute number of cells, and the increase in hemocytoblast numbers. There was also a progressive increase in erythrocyte population. By the time Group 2R had been sacrificed close examination was required to distinguish the tissues from normal.

Table VIII contains the data obtained from differential counts made on the marrow taken from the irradiated animals. Part of the data obtained from this group is presented in Graphs V to VIII. The number of cells per given area was observed in fat deposition in the marrow. As in the protein deficient animals, there was a marked increase in the megakaryocyte, lymphocyte, and neutrophil ratios. The hemocytoblast ratio first increased and then declined to normal values in the animals of longer duration. Their controls presented a cytological picture similar to the older control animals in the protein experiment.

Geiger Count Results

Graph VIII contains the data obtained from a series of Geiger counts made on the live animals which had previously been injected intraperitoneally with 10 micrograms of radium chloride. According to Stranathan (1948) radium and its disintegration product, radon, are alpha particle emitters. However, the disintegration products of radon are gamma emitters of short half life. The range of alpha particles is so short that they will not even penetrate the skins of the animals; therefor, it is impossible by Geiger count methods to make use of the alpha radiation. However, it is possible to measure the gamma radiation from the disintegration products of radon. In order to determine quantitatively the amount of radium present by measurement of the gamma emission from the disintegration products of radon their must exist a known ratio between the amount of radon corresponding to a quantity of radium. This is the case when radium and radon are in radioactive equilibrium, since the ratio of the amount of radon to the amount of radium present is constant. The radium content of the animals can then be determined by comparing the Geiger counts with those of a known amount of radium which is in radioactive equilibrium if the radium injected animals are sacrificed, sealed in containers, and laid aside for 38 days. At this time the rate of disintegration of radon becomes equal to the rate at which it is being formed. When this point is reached, radium and radon are said to be radioactive equilibrium.

Hoecker and Roofe (1951) have pointed out that approximately 70% of the radium injected in an animal is excreted within 15 to 20 days and that the remaining 30% is permanently retained in the bones of the animals. This radium is constantly disintegrating to radon, which is an inert gas. The amount of radon in the live animal is then equivalent to the difference between the rate of its production and elimination. The rate of elimination is dependent upon biological excretion and radioactive disintegration. As shown in Graph VIII the Geiger counts of the live animals indicate that very little change in the amount of radon retained in the animals occurred after 21 days. This would definitely indicate that an equilibrium had been attained between the rates of production and elimination of radon in the live animals. As yet no means of calculating the amount of radium present in a live animal has been determined. However, if further investigation reveals a constant ratio to exist between the amount of radon in the live animal and the amount of

radium retained in the animal's body, it will be possible to ascertain by Geiger counts the exact amount of radium present in the live animal.

GENERAL AND HISTOCHEMICAL OBSERVATIONS OF TISSUES

The development of fat vacuoles in the bone marrow of the protein deficient animals has been considered previously in this paper. In addition, it was observed that there was a decrease in mitotic activity in the marrow. The cell types present in the tissue sections were preponderantly mature cells, especially those in the neutrophil series. An occasional megakaryocyte appeared to be fragmenting in both the protein deficient and irradiated animals. This is indicative of their presumed function of producing blood platelets. Tissues taken from the recovery animals showed a great deal of mitotic activity. The marrow taken from the irradiated animals showed little or no change in mitotic activity; however, nuclear and cytoplasmic disintegration of some of the formed elements was observed. These cells were probably the targets of alpha particles and show a decrease in both cytoplasmic and nuclear absorption of the dye.

The absorption of toluidine blue varied only slightly in the marrow taken from experimental animals and their controls. In the protein deficient animals there was a definite drop in total tissue absorption of the dye due to fatty infiltration. At times there appeared to be a slight decrease in the cytoplasmic absorption, but this was not consistent. The only change in cellular absorption in the irradiated animals was noted above, that is, a decrease in absorption in disintegrating cells. The majority of cells which were undergoing disintegration seemed to be immature erythrocytes. This would coincide with the relative drop in erythrocyte numbers.

DISCUSSION

For a portion of the protein experiment, Trahan (1951) made manometric studies of the bone marrow extracted from the sacrificed animals. From his studies he found an 18% drop in the Q_{O_2} of the protein deficient animals. His studies also included peripheral blood studies in which he found a drop in hematocrit, hemoglobin, erythrocytes, and lymphocytes. He also found an increase in peripheral neutrophil count of 263%. Although many of his data were obtained from a different group of similarly treated animals, this data helps explain some of the data obtained in this experiment. In both the bone marrow and peripheral studies there

was found a drop in erythrocyte numbers and an increase in neutrophil numbers. The drop in tissue activity due to fatty infiltration is substantiated by the drop in Q_{O_2} of the tissues.

Orten and Orten (1937 and 1939) found that rats fed low protein diets developed hypochromatic anemia with a normal red cell count. They found this condition could be corrected by administration of protein to the diet. Wright and Skaggs (1946), in a similar experiment, reported a slight drop in red cell count and a reduced hemoglobin value.

Benditt (1947) also did work with rats on protein free diets, and found that hypoproteinemia resulted. He and his co-workers experimented with diets varying the amino acids, and came to the conclusion that a dietary deficiency of protein or a single essential amino acid, with the exceptions of arginine or leucine, resulted in a reduced number of erythrocytes and a drop in hemoglobin in the peripheral blood.

Very little work has been done on the effects of diet on hemopoietic tissue. Brown (1954) studied the effects of protein deficiency on both peripheral blood and bone marrow. His results on peripheral studies are in close agreement with those already stated. He did, however, find that peripheral leucopenia also resulted and reported a drop in the peripheral platelet count. His studies of bone marrow indicated a drop in immature cells of the myeloid and erythroid series, and a decrease in all types of cells, including the megakaryocytes. He also reported the myeloid/erythroid ratio to remain fairly constant. In this experiment there was found a relative increase in megakaryocytes and a definite increase in the myeloid-erythroid ratio. The methods of counting and staining used may explain this difference in results. Brown (1954) stained with hematoxylin and eosin, and the bone marrow in this experiment was stained with toluidine blue. Brown selected myeloid, erythroid, and mixed fields, and used a camera-lucida for counting. In this experiment, the fields were selected at random and the previously described pointer system was used for counting.

Hoecker and Roofe (1951) have found that in the bones of rats sacrificed soon after injection, the highest concentration of radium is in the periosteum and endosteum. In rats sacrificed several months after injection they observed that the concentration is greatest in the newly formed bone. They also found a similarity existing between radium deposition and optically dense areas in the bone. They report that 96% of the total energy emitted by radium in total disintegration is associated with alpha particle emission.

Of the remaining 4% only a fraction is absorbed by the body and its effects can be considered negligible.

In a series of studies done by Bloom (1948) using external and internal sources of irradiation, it was found that cessation of mitosis, pyknosis, and fragmentation of the cells occurred. He observed a greater proportion of debris resulting from destruction of red blood cells than from white blood cells. He found that the granulocytopoietic cells disappeared less rapidly than the erythropoietic. He reported an initial decrease in megakaryocyte numbers with a later return to normal and above. He concluded, "Irrespective of species or type of radiation, erythroblasts were more sensitive than myelocytes, and myelocytes more sensitive than megakaryocytes." This was found to be the case in this experiment.

Roofe, Bingham, and Comer (1951) in a short-term experiment using intraperitoneally injected radium chloride found that megakaryocyte and blood platelet numbers fell off immediately after injection with megakaryocyte numbers returning to near and above normal after 14 days. In the present study, the megakaryocyte numbers were found to be considerably above normal by the fourteenth day with a continuing rise to the thirty-fifth day.

Roofe and Bingham (1953) used intraperitoneally injected radium chloride and found that in the bone marrow neutrophils and eosinophils increased in number with time. The erythroid series dropped initially with a tendency to increase with time. At the same time, peripheral polymorphonuclear leucocytes dropped, with the R. B. C. count remaining normal. Dunlop (1942) also found an increase in bone marrow neutrophils with a decrease in peripheral neutrophils. Both authors found an increase in the myeloid-erythroid ratio in the bone marrow. This agrees with the results found in the present study. Such a rise in bone marrow neutrophils and increase in peripheral count suggest some factor which might cause retention of mature granulocytes. Perhaps there is also some factor which permits the peripheral erythrocyte members to be maintained in spite of relative decreases in bone marrow concentration.

According to Davidson (1950), the highly cellular organs such as spleen, thymus, pancreas, and bone marrow are rich in nucleic acid, whereas organs like brain or muscle have a lower content. In tissues with a high nuclear-cytoplasmic ratio the concentration of DNA is high, but in tissues with a high concentration of cytoplasmic granules, RNA content is high. He also finds a good correlation between cytoplasmic basophilia and RNA content of the tissues. He points out that embryonic tissues have been found to

have higher nucleic acid content than adult. Since the similarity of dye absorption in the experimental and control animals, in this experiment, indicates little or no change in cellular basophilia, it seems plausible to suggest that cellular nucleic acid content was not changed by the procedures used in this experiment. Since nucleic acids play such a vital part in cellular activities it seems logical that their concentrations should be preserved at all costs.

SUMMARY

Two groups of experimental animals were used in this experiment. The animals in the first group were subjected to protein fast and the animals in the second group were injected intraperitoneally with radium chloride. Differential counts were made by a random selection procedure on the bone marrow taken from these animals. Toluidine blue was used as the stain to determine the effect the protein fast and irradiation had on the nucleic acid content of the tissue.

1. Cellular basophilia and nucleic acid content is not noticeably affected by protein fast and radiation under the conditions described in this experiment.
2. Total bone marrow basophilia and nucleic acid content is reduced during protein fast due chiefly to reduction in cellularity.
3. Fatty displacement of tissue occurs in bone marrow during protein fast.
4. Mitotic activity is decreased by both protein fast and radiation.
5. Changes which take place in the bone marrow during protein fast are overcome when animals are returned to normal protein diets.
6. The myeloid/erythroid ratio increases during protein fast and following irradiation.
7. In the bone marrow erythropoietic elements are the most easily affected by protein fast and internal irradiation, and granulocytopoietic elements are more susceptible than are the megakaryocytes.

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EXPLANATION OF GRAPHS AND TABLES

GRAPHS I to VII

Ordinates show number of cells per 100 erythrocytes.

Abscissae show time.

Group A—Purina fox chow diet animals

Group B—18% protein diet animals

Group C—0.0% protein diet animals

Group R—Recovery animals

Group Ra—Radium injected animals

Group N—Controls for injected animals

Line connecting groups C and R does not represent animals in the series but is to show relationship of the two groups.

Only average values are shown on these graphs because of the small spread in the data obtained from counts.

GRAPH VIII

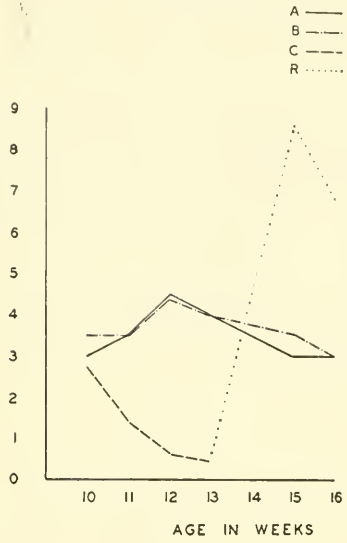
The ordinate expresses the number of Geiger counts recorded from radium injected animals as the percent of the counts recorded from a 1 microgram standard which was in radioactive equilibrium.

GRAPHS I to IV

GRAPH I

HEMOCYTOBLAST PROTEIN

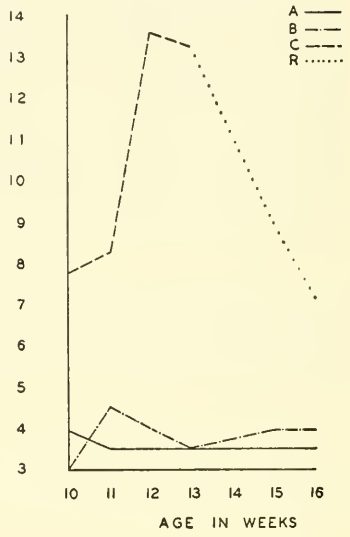
HEMOCYTOBLASTS PER 100 ERYTHROCYTES



GRAPH II

MEGAKARYOCYTE PROTEIN

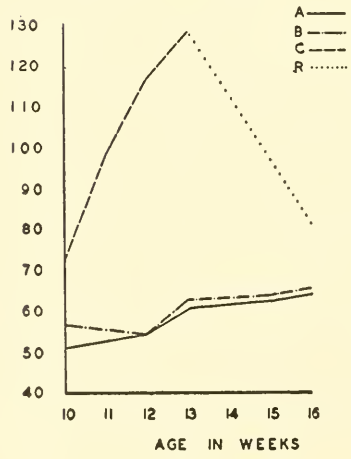
MEGAKARYOCYTES PER 100 ERYTHROCYTES



GRAPH III

NEUTROPHIL PROTEIN

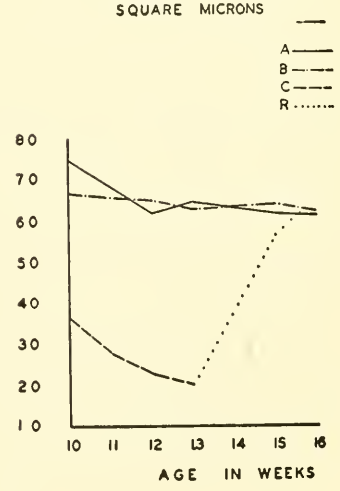
NEUTROPHILS PER 100 ERYTHROCYTES



GRAPH IV

BLOOD CELLS PROTEIN

NO. CELLS PER 2500 SQUARE MICRONS

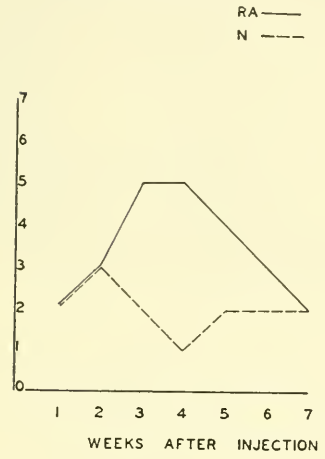


GRAPHS V to VIII

GRAPH V

HEMOCYTOBLAST RADIATION

HEMOCYTOBLASTS PER
100 ERYTHROCYTES



GRAPH VI

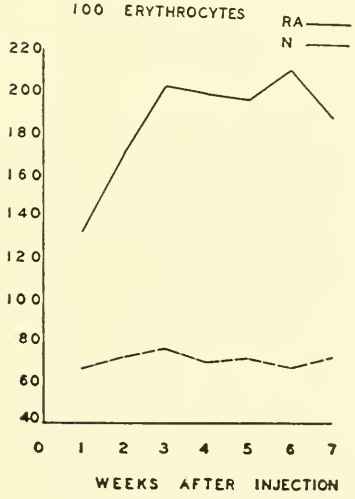
MEGAKARYOCYTE RADIATION

MEGAKARYOCTES PER
100 ERYTHROCYTES

GRAPH VII

NEUTROPHIL RADIATION

NEUTROPHILS PER
100 ERYTHROCYTES



GRAPH VIII

GEIGER COUNTS RADIATION

POINTS REPRESENT OF STANDARD
STANDARD = 1 MICROGRAM RADIUM
0 = INJECTION DATE

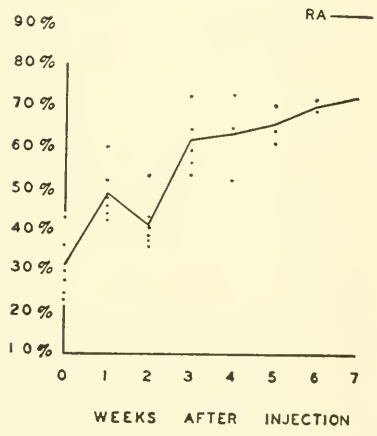


TABLE I

RAT DIETS *

General Biochemicals	*Amounts*
Casein for Diet A, 0.0%	0.0 grams
Casein for Diet B, 18%	540 grams
Sucrose or dextrin, 93% (Beet or Cane Sugar)	2790 grams
Corn oil, 2% (Mazola Oil)	60 grams
1:20 liver extract, 1%	30 grams
B_1	16 Mg.
B_6	16 Mg.
Riboflavin	15 Mg.
Niacin	39 Mg.
Calcium Pantothenate	16 Mg.
Choline Chloride	3 grams
Haliver oil	1 drop per week per animal
L—Tocopherol Vitamin E	1 drop every 4 weeks per animal
Salts, 4% (by G. B. I. after Hubbel, Mendel, and Wakeman)	120 grams

* Modified from diets used by Brown (1954).

TABLE II.—Weight Variations of Animals During Protein Experiment

All weights expressed in grams
A=Purina fox chow diet animals
B=18% protein diet animals

Animal	1st day	4th day	7th day	10th day	12th day	14th day	17th day	18th day	21st day	24th day	26th day	28th day	31st day	33rd day	35th day	38th day	40th day	42nd day	45th day	47th day	49th day	52nd day	54th day	56th day	Percent change + or —
1 A1	177	185	198	207	221	234	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+32%
1 A2	165	175	193	204	210	218	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+32%
2 A1	175	184	193	203	214	224	245	260	280	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+60%
2 A2	179	186	195	201	223	235	250	263	286	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+60%
3 A1	174	184	192	200	208	213	243	261	280	286	292	295	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+69%
3 A2	156	166	175	190	208	220	237	251	260	265	272	280	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+79%
4 A1	167	177	190	199	206	212	245	260	280	282	286	290	300	306	316	.....	.....	.....	.....	.....	.....	.....	.....	.....	+89%
4 A2	160	172	187	194	201	213	238	256	274	282	288	291	305	309	313	.....	.....	.....	.....	.....	.....	.....	.....	.....	+97%
5 A1	164	172	177	194	204	230	252	276	280	286	290	299	301	307	313	320	327	335	337	339	342	.....	.....	.....	+108%
5 A2	170	176	184	190	196	208	230	250	268	281	288	296	300	306	314	323	331	340	342	344	346	.....	.....	.....	+103%
6 A1	150	165	180	196	204	210	229	242	257	263	268	270	282	293	300	310	314	320	330	335	340	344	346	350	+133%
6 A2	169	174	186	198	210	216	230	243	260	268	275	282	291	298	308	316	324	331	340	346	350	355	360	361	+114%
1 B1	158	165	176	187	198	210	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+27%
1 B2	156	163	175	185	194	206	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+32%
2 B1	156	164	174	186	198	208	225	236	248	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+59%
2 B2	164	170	179	188	201	214	230	242	256	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+56%
3 B1	154	162	176	186	194	205	218	233	246	258	268	276	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+79%
3 B2	160	165	178	190	199	208	220	235	248	266	274	283	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+77%
4 B1	152	160	171	181	193	204	216	226	239	250	262	274	290	301	310	.....	.....	.....	.....	.....	.....	.....	.....	.....	+104%
4 B2	168	175	186	198	210	218	224	233	248	266	280	299	306	314	318	.....	.....	.....	.....	.....	.....	.....	.....	.....	+90%
5 B1	160	172	187	194	204	213	237	257	276	281	290	290	306	318	324	329	327	330	333	336	339	.....	.....	.....	+112%
5 B2	176	184	193	200	218	229	241	255	275	286	294	290	308	323	330	336	341	345	348	351	353	.....	.....	.....	+108%
6 B1	155	166	175	188	209	220	231	243	262	274	281	290	299	308	314	326	333	340	342	345	345	348	352	356	+130%
6 B2	160	170	185	194	205	210	226	248	266	276	284	292	301	310	316	330	331	341	344	346	348	350	354	358	+124%

TABLE III.—Weight Variations of Animals During Protein Experiment

All weights expressed in grams
C=0.0% protein diet animals

Animal	1st day	4th day	7th day	10th day	12th day	14th day	17th day	19th day	21st day	24th day	26th day	28th day	31st day	33rd day	35th day	Percent change + or —	Average percent change
1 C1	161	146	140	134	128	124	.....	.....	.....	.....	.....	.....	.....	.....	.....	—23%	
1 C2	178	169	146	138	134	130	.....	.....	.....	.....	.....	.....	.....	.....	.....	—27%	
1 C3	168	152	140	130	126	124	.....	.....	.....	.....	.....	.....	.....	.....	.....	—26%	
1 C4	170	152	138	128	126	124	.....	.....	.....	.....	.....	.....	.....	.....	.....	—27%	
1 C5	190	170	153	132	130	130	.....	.....	.....	.....	.....	.....	.....	.....	.....	—32%	—27%
2 C1	161	150	148	143	140	135	131	128	125	.....	.....	.....	.....	.....	.....	—23%	
2 C2	168	148	142	136	128	120	120	116	114	.....	.....	.....	.....	.....	.....	—32%	
2 C3	168	152	140	130	126	122	120	120	118	.....	.....	.....	.....	.....	.....	—30%	
2 C4	168	152	138	132	130	130	126	125	124	.....	.....	.....	.....	.....	.....	—26%	
2 C5	170	152	146	140	135	130	128	125	124	.....	.....	.....	.....	.....	.....	—27%	—28%
3 C1	166	135	132	130	121	108	106	103	100	99	96	93	.....	.....	.....	—42%	
3 C2	162	140	138	136	120	110	108	105	102	100	99	96	.....	.....	.....	—41%	
3 C3	164	138	137	136	120	114	110	108	108	107	103	100	.....	.....	.....	—39%	
3 C4	176	156	142	134	130	126	125	124	124	120	119	114	.....	.....	.....	—35%	
3 C5	166	152	142	130	129	128	128	126	124	120	118	114	.....	.....	.....	—31%	—37%
4 C1	161	150	147	143	130	124	124	126	127	117	112	110	108	106	103	—36%	
4 C2	166	152	148	146	132	122	120	120	118	117	114	110	108	105	104	—37%	
4 C3	164	148	144	134	133	130	128	126	126	124	120	118	117	115	114	—31%	
4 C4	164	148	140	136	130	120	120	118	116	110	109	106	100	99	94	—37%	
4 C5	148	136	130	124	120	114	111	109	110	108	102	100	99	96	96	—35%	—35%

TABLE IV.—Weight Variations of Animals During Protein Experiment

All weights expressed in grams
R=recovery animals
0.0% protein diet for 35 days

Animal	1st day	4th day	7th day	10th day	12th day	14th day	17th day	18th day	21st day	24th day	26th day	28th day	31st day	33rd day	35th day	38th day	40th day	42nd day	45th day	47th day	49th day	52nd day	54th day	56th day	Percent change + or —	Average percent change
1 R1	147	130	126	123	120	114	110	109	107	105	101	100	96	95	93	126	139	152	180	196	210	.....	.....	.....	+43%	.....
1 R2	176	158	150	140	139	134	133	131	130	128	126	124	119	118	160	182	204	232	249	260	261	.....	.....	.....	+48%	.....
1 R3	170	152	146	136	130	122	122	121	120	118	116	112	111	109	108	148	175	190	223	238	246	.....	.....	.....	+45%	.....
1 R4	164	148	136	128	124	118	117	116	116	109	107	106	104	103	102	138	152	176	207	222	232	.....	.....	.....	+41%	.....
1 R5	164	148	136	128	122	116	112	110	108	106	104	100	97	93	90	133	148	162	189	200	210	.....	.....	.....	+28%	+41%
2 R1	161	148	136	134	130	124	122	121	120	118	114	110	109	109	108	138	149	165	187	200	215	239	248	255	+58%	.....
2 R2	128	116	110	108	106	100	99	97	98	96	94	90	89	88	88	128	139	154	175	192	201	220	226	230	+80%	.....
2 R3	174	152	144	138	132	126	124	120	118	116	114	110	109	106	106	142	160	188	221	232	244	260	273	280	+61%	.....
2 R4	180	160	150	144	136	130	128	127	126	124	120	118	116	112	108	143	159	176	217	226	230	246	258	264	+47%	.....
2 R5	150	134	128	120	118	114	116	115	112	108	106	100	99	100	100	143	161	178	213	224	236	249	260	272	+81%	+65%

TABLE V.—Weight Variations of Animals During Radiation Experiment

All weights expressed in grams
Ra = irradiated animals
N = control animals

Animal	Injection date	3rd day	5th day	7th day	10th day	12th day	14th day	17th day	19th day	21st day	24th day	26th day	28th day	31st day	33rd day	35th day	38th day	40th day	42nd day	45th day	47th day	49th day	Percent change + or −
Ra 1	508	500	497	495																			− 2.6%
Ra 2	505	495	490	488	490	492	493																− 2.4%
Ra 3	440	430	426	424	424	425	426	416	410	408													− 7.3%
Ra 4	555	550	548	546	540	542	536	530	525	520	518	517	515										− 4.0%
Ra 5	537	533	530	527	521	518	517	514	512	510	505	500	498	495	494	492							− 8.4%
Ra 6	511	504	500	499	497	495	493	490	490	489	487	484	485	484	484	483	480	475	470				− 8.0%
Ra 7	465	458	454	452	440	435	433	428	426	423	420	420	418	411	409	407	401	398	395	393	390	388	−16.5%
N 1	506	505	508	510																			− 0.8%
N 2	525	525	526	527	526	528	528																− 0.6%
N 3	510	510	509	508	509	510	510	511	512														− 0.4%
N 4	530	531	529	527	528	526	526	526	526	526	528	530	530										− 0.0%
N 5	543	545	545	547	548	550	548	548	547	546	547	549	550	550	551	551							− 1.5%
N 6	489	490	493	495	495	496	499	503	502	504	505	505	506	505	505	505	507	508	508				− 3.9%
N 7	493	493	495	499	502	504	555	504	506	509	511	510	511	512	513	514	515	514	515	516	516	515	− 4.7%

TABLE VI.—Cell Counts for Protein Experiment Animals

A=Purina fox chow diet animals
B=18% protein diet animals

Animal	Hemocytoblast	Megakaryocyte	Lymphocyte	Eosinophil	Neutrophil	Erythrocyte	No. cells per 2500 microns	Time
1 A1	3	4	16	7	50	100	76	14 days
1 A2	4	4	14	6	52	100	74	14 days
2 A1	3	4	15	5	55	100	68	21 days
2 A2	3	3	16	4	51	100	68	21 days
3 A1	5	3	15	5	57	100	62	28 days
3 A2	4	4	17	3	54	100	63	28 days
4 A1	5	4	16	6	60	100	65	35 days
4 A2	3	3	14	4	64	100	63	35 days
5 A1	4	4	14	5	62	100	62	42 days
5 A2	2	3	18	3	66	100	62	42 days
6 A1	3	5	15	4	65	100	61	49 days
6 A2	3	4	15	4	67	100	62	49 days
1 B1	3	3	20	7	60	100	68	14 days
1 B2	4	3	16	5	52	100	67	14 days
2 B1	4	4	17	6	55	100	66	21 days
2 B2	3	5	15	4	56	100	66	21 days
3 B1	5	4	14	5	52	100	65	28 days
3 B2	4	4	17	3	58	100	66	28 days
4 B1	5	3	13	4	60	100	64	35 days
4 B2	3	4	15	4	62	100	63	35 days
5 B1	4	5	16	5	61	100	64	49 days
5 B2	3	3	13	4	64	100	64	49 days
6 B1	4	4	17	6	63	100	63	56 days
6 B2	2	4	18	5	66	100	62	56 days

TABLE VII.—Cell Counts for Protein Experiment Animals

C=0.0% protein diet animals
R=recovery animals

ANIMALS	Hemocytoblast	Megakaryocyte	Lymphocyte	Eosinophil	Neutrophil	Erythrocyte	No. cells per 2500 sq. microns	Time
1 C1	5	8	20	7	75	100	36	
1 C2	3	7	19	7	73	100	32	
1 C3	2	8	21	6	78	100	37	14 days
1 C4	2	7	20	5	80	100	38	
1 C5	2	9	20	7	80	100	38	
2 C1	2	8	19	6	96	100	27	
2 C2	1	9	22	8	98	100	28	
2 C3	1	9	21	8	101	100	29	21 days
2 C4	1	8	20	7	97	100	28	
2 C5	1	10	23	6	102	100	30	
3 C1	1	12	27	8	122	100	25	
3 C2	0	12	25	8	114	100	25	
3 C3	0	11	26	6	113	100	22	28 days
3 C4	0	13	28	5	115	100	23	
3 C5	1	10	24	6	118	100	22	
4 C1	1	12	25	5	128	100	20	
4 C2	0	14	26	7	123	100	21	
4 C3	0	14	26	7	127	100	19	35 days
4 C4	1	13	27	6	130	100	20	
4 C5	1	14	26	6	131	100	20	
1 R1	10	10	26	6	96	100	56	
1 R2	8	9	22	4	94	100	52	
1 R3	10	10	21	6	90	100	58	49 days
1 R4	9	8	26	5	101	100	58	
1 R5	7	8	25	7	100	100	57	
2 R1	8	8	22	6	77	100	66	
2 R2	6	8	19	4	80	100	67	
2 R3	7	6	18	5	85	100	68	56 days
2 R4	6	5	22	6	79	100	66	
2 R5	7	6	20	6	86	100	64	

TABLE VIII.—Cell Counts for Radiation Experiment Animals

Ra = irradiated animals
N = control animals

ANIMAL	Hemocytoblast	Megakaryocyte	Lymphocyte	Eosinophil	Neutrophil	Erythrocyte	Time
Ra 1	2	4	22	6	132	100	7 days
Ra 2	3	10	32	4	170	100	14 days
Ra 3	5	13	26	4	202	100	21 days
Ra 4	5	15	34	6	197	100	28 days
Ra 5	4	16	22	4	196	100	35 days
Ra 6	3	15	37	6	210	100	42 days
Ra 7	2	12	26	3	186	100	49 days
N 1	2	3	18	4	66	100	7 days
N 2	3	3	17	4	72	100	14 days
N 3	2	4	17	3	74	100	21 days
N 4	1	2	16	4	70	100	28 days
N 5	2	5	19	3	72	100	35 days
N 6	2	3	22	3	68	100	42 days
N 7	2	2	20	3	71	100	49 days

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Taxonomy and Ecology of Kansas Hepaticae [1]

BY

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ABSTRACT.—This paper reports 69 taxa of hepatics for Kansas. Most are ubiquitous species found over most of North America and elsewhere but not previously known from Kansas. A number of significant extensions of range are reported and more information is given for a few taxa recently reported for North America.

Morphological variations of the taxa are discussed where they differ from those reported in the literature or are important in problems of speciation.

The ecology of Kansas Hepaticae is considered in relation to soils, climate, higher plant associations, invasion and succession. The hepatic flora of Kansas is most closely related to that of the south, particularly the Edwards Plateau of Texas.

INTRODUCTION

During the 90 years of botanical activity in Kansas, prior to the present work, the Hepaticae received little attention. A few publications mentioned liverworts and a few lists were prepared. It is significant that Frye and Clark (1937-'47) list one species only from the State indicating that the general literature contained little on this group of plants in Kansas.

The first paper to report an hepatic from Kansas was that of Carruth (1873) in which he listed *Marchantia polymorpha* from Douglas County. Cragin (1884) noted Carruth's paper and reported *Reboulia hemisphaerica* from Clay and Ottawa Counties. Smyth and Smyth (1911) included 25 species of hepatics in their catalogue of the Flora of Kansas. Lorenz (1915) reported *Riccia frostii* from the State and Thompson (1948) reported *Sphaerocarpus michelii* and *Sphaerocarpus texanus*. Gier (1949) published a list of Kansars Hepaticae in which he listed 25 species based on the publication of Smyth and Smyth (1911). McGregor (1952) reported

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Riccia rhenana and Wittlake (1953) reported *Oxymitra androgyna* from the State. In most of these papers the hepatics are mentioned only incidental to other objectives or are merely lists of species occurring in the State, or new to the State.

For the past seven years the author has made an extensive and intensive study of the Hepaticae of Kansas. Each of the 105 counties has been visited and all habitat types occurring in the State have been observed. Most of these habitat types have been studied many different times and throughout all seasons of the year. A collection of each species was made from each location as it was found. In addition the same species was again collected from the same site at various times during the growing seasons. For each collection detailed notes were made to cover collection data, abundance and ecological conditions.

It is not the purpose of this work to prepare a taxonomic manual of the Hepaticae of Kansas but rather it is an attempt to record all species found to occur in the state, their abundance, morphological variations and to give a detailed study of their ecology in relation to other Hepaticae and to other vegetation. Such a study has never been made in this region of the United States. The only works to cover the ecology of a hepatic flora anywhere in the United States are the important publications on Central New York State by Schuster (1949) and the equally important work on Minnesota by Schuster (1953). Sharp (1939) included some ecological data on hepatics in his publication on Eastern Tennessee Bryophytes but for the most part his work is concerned with mosses. Many other papers have included a limited amount of hepatic ecologic data but not a complete account for a hepatic flora in a definite area of any size.

It was therefore considered worth-while to study the hepatic flora of a state located in the center of the United States—one in which the vascular flora shows a transition from the eastern forest areas to the short-grass prairies, and at the same time, one that includes northern, southeastern, and strong southern floristic affinities.

This work is divided into two parts. The first section is concerned with the taxonomic studies, referred to above, and the second section describes the ecology of the different taxa.

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TAXONOMIC STUDIES

In the following list are included all the described taxa of hepatics now known to occur in the state of Kansas. For each are given brief notes on the habitats, comparative frequency, distribution by counties and other pertinent taxonomic or morphological features.

At present the annotated list includes 69 taxa. This is believed to include nearly all the hepatics to be found in the State since few additional species have been found during the last two seasons.

The arrangement of taxa follows, in general, that of Schuster (1953) in so far as order of families and genera are concerned. The species are arranged alphabetically under each genus. Since most collections have been made by the writer they will be simply designated by placing an M before the collection number. All other records are designated by usual standard abbreviations. Unless otherwise mentioned all collections are deposited in the Herbarium of the University of Kansas.

ANTHOCEROTACEAE

1. *Anthoceros crispulus* (Mont.) Douin. Uncommon in our area but found in prairie swales where the characteristic plant association is dominated by *Andropogon gerardi* and *Tripsacum dactyloides*. It has also been found once in an overgrazed pasture near a pond. In all habitats the soil was loam or clay, moist, and shaded.

As noted by various authors *A. crispulus* is very closely related to *A. punctatus*. Proskauer (1948) who merged the two considered *A. crispulus* to be a phase or modification of *A. punctatus* with surface outgrowths "especially in plants from relatively dry situations." This concept may be correct but the writer has not been able to verify it so far as Kansas material is con-

cerned. *A. punctatus* has been found in several habitats much drier than those in which material referred to *A. crispulus* has been found and no sign of surface outgrowths has been noted. In one habitat hundreds of specimens of typical *A. crispulus* were found and nothing referable to *A. punctatus* could be discovered. Yet, less than a mile away and on a drier prairie slope only *A. punctatus* could be found. In addition to the fact that the dorsal surface bears crowded lamellae (characteristic of *A. crispulus* but not of *A. punctatus*) Kansas material of *A. crispulus* has pseudoelaters often 3-5 cells long and measuring up to 210μ long, while *A. punctatus* has pseudoelaters only 1-2 cells long and 60-100μ long. However the range of the number of cells and length of pseudoelaters overlap in both and do not always allow for easy separation on these points alone. Until more information is obtained it seems best to consider the two as separate taxa.

Distribution: *Douglas County:* 1 mile west of Pleasant Grove, in bluestem prairie, July 18, 1951, M4987; July 24, 1951, M5001. *Jackson County:* 1 mile west of Hoyt, bluestem prairie, August 22, 1951, M5076. *Johnson County:* near De Soto, prairie pasture, October 2, 1951, R. H. Thompson. *Leavenworth County:* 3 miles northeast of Tonganoxie, bluestem prairie, August 4, 1951, M5007.

2. *Anthoceros punctatus* L. Rather widely distributed in the eastern half of the State where it is found commonly on moist sandy soil in prairie dominated by *Andropogon gerardi, Sorghastrum nutans* and *Tripsacum dactyloides.* It also occurs occasionally on alluvial deposits of creek banks, sandy oak-hickory woodlands, overgrazed prairie pastures, and along paths or trails in the sand dune areas of central Kansas.

The occurrence of the species in the state is directly related to rainfall. A dry winter and spring such as occurred in 1952-53 prohibits the appearance of the species for the season. During the 1953 season not a single mature plant was found while in contrast the very wet season of 1951 revealed an abundance of plants.

It should be noted that in Kansas the species occurs most frequently in relatively moist, sandy prairie and less commonly on limestone prairie. Its occurrence in woodlands is usually in close association with such prairie areas and the occurrence on alluvial deposits is attributed to water dispersal.

The frequency of occurrence of this species was determined by use of meter quadrats dispersed at random in a prairie area.

It was found than an average of 33 plants per meter quadrat existed in a prairie of some 160 acres. Most of these occurred around the base of *Andropogon gerardi* clumps. A casual study of such an area might lead one to believe that the usual habitat was along the moister drainage areas. However, the large number of plants found along moist ditches and banks seems to be due to a concentration of spores by drainage from the "mother lode" which actually is dispersed over a large area and thus might escape notice. The same condition is to be found in forested areas.

Kansas specimens of *A. punctatus* seem to agree with descriptions given for the species except that they are usually at the lower range given for size of the thallus and length of the sporangium.

Distribution: *Allen County:* 5 miles north of Moran, alluvial deposit on creek bank, October 8, 1948, M2503; 1 mile south of Humboldt, oak wooded hillside, July 7, 1949, M3334. *Anderson County:* 5 miles south of Garnett, creek bank, October 8, 1948, M2488; 2 miles south of Garnett, clay soil in oak woods, June 4, 1951, M4877. *Bourbon County:* 2 miles south of Uniontown, rocky, moist hillside, October 8, 1948, M2514; 1 mile south of Uniontown, creek bank, July 7, 1949, M3344. *Cherokee County:* 5 miles east of Baxter Springs, clearing in oak woods, April 30, 1948, M1363; 5 miles east of Baxter Springs, creek bank, July 31, 1948, M1939. *Clay County:* 5 miles north of Morganville, sandy bluestem prairie, August 16, 1951, M5069. *Cloud County:* on soil, September 13, 1948, Rev. S. V. Fraser. *Crawford County:* lespedeza pasture, November 24, 1949, L. J. Gier 2952. *Douglas County:* 2 miles southeast of Baldwin City, creek bank, November 2, 1947, M1133; 1 mile west of Pleasant Grove, swale in bluestem prairie, July 24, 1951, M4999. *Ellsworth County:* 3 miles northeast of Carneiro, low moist prairie, May 22, 1948, M1499. *Franklin County:* 1 mile southeast of Ottawa, wooded hillside, June 28, 1949, M3308. *Harvey County:* 5 miles north of Burrton, cattle trail through sand dunes, June 11, 1951, M4915. *Jackson County:* 1 mile west of Hoyt, bluestem prairie, August 22, 1951, M5075. *Leavenworth County:* 4 miles northeast of Tonganoxie, sandy bluestem prairie, May 7, 1948, M1408; 2 miles west and 1 mile south of Linwood, sandy oak-hickory woods, June 16, 1949, M3086. *Montgomery County:* 3 miles south of Elk City, sandy oak woods, April 4, 1942, R. H. Thompson. *Nemaha County:* sandy bluestem prairie, August 9, 1948, M2018. *Osage County:* 6 miles south of Quenemo, moist

bank in oak woods, July 1, 1949, M3324. *Ottawa County:* Ottawa County State Park, seepy area below sandstone outcrop, May 21, 1948, M1466. *Reno County:* 6 miles northeast of Hutchinson, cattle path through sand dunes, June 11, 1951, M4955. *Saline County:* 2 miles northwest of Brookville, moist sandy prairie ravine, May 22, 1948, M1478. *Washington County:* 2 miles southwest of Palmer, sandy bluestem prairie, May 27, 1951, M4827. *Wilson County:* 1 mile northeast of Neodesha, open sandy oak woods, April 10, 1948, M1271. *Woodson County:* 2 miles northwest of Yates Center, on shallow soil over surfacing sandstone in prairie, April 9, 1948, M1244; Lake Fegan, sandy path in oak woods, June 19, 1949, M3191.

3. *Phaeoceros laevis* (L.) Proskauer. Found commonly on shaded moist sandstone ledges, less frequently on creek banks, seepy areas below ledges and springs. It rarely occurs elsewhere and seldom with *Anthoceros punctatus* and *A. crispulus.* It is an almost constant associate with *Conocephalum conicum, Plectocolea hyalina,* and often with *Reboulia hemisphaerica.*

P. laevis occurs characteristically as extensive mats on the sides of shaded, moist sandstone ledges along creek banks, ravines and often on boulders in stream beds.

Kansas material of *P. laevis* seems to match closely the descriptions given for the species. However, in some of the collections from very moist habitats mature specimens often exhibit the characters of *Phaeoceros carolinianus* (Michx.) Proskauer in that the involucres do not flare and marginal glandular thickenings are to be found. These characters are by no means constant and seem to intergrade with *P. laevis* in which the involucre does flare at the summit and glandular thickenings are rare. One colony, represented by collections M1058, M3105, M4147, M4673 and M5003, has been studied each year from 1947 through 1953. Usually a few involucres do not flare at the mouth and some glandular thickenings do occur but in 1951, a year of record rainfall, most of the involucres did not flare and glandular thickenings were rather frequent. It thus seems best not to consider *P. carolinianus* as a distinct taxon. Schuster (1953) noted these conditions and reduced *carolinianus* to a forma of *P. laevis.* It might be best considered thus, but Kansas material intergrades so completely that separation here seems unwarranted.

Distribution: *Anderson County:* 5 miles south of Garnett, creek bank, October 8, 1948, M2489. *Chautauqua County:* 3 miles northeast of Sedan, moist sandstone ledge, July 1, 1947, M1073; 1½ miles northeast of Sedan, on moist sandstone rocks, July 8, 1949, M3381.

Douglas County: 5 miles west of Baldwin City on moist sandstone ledge, June 24, 1947, M1058; June 18, 1949, M3105; October 15, 1949, M4147; September 16, 1950, M4673; August 2, 1951, M5003. *Elk County:* 10 miles north of Busby, sandy soil below a spring, July 27, 1948, M1917. *Franklin County:* 4 miles southwest of Ottawa, moist sandstone ledge, June 18, 1949, M3097. *Greenwood County:* near Severy, September 2, 1945, R. H. Thompson; 5 miles northeast of Fall River, moist sandstone ledge, July 17, 1947, M1075; 1 mile east of Fall River, on moist sandstone rocks, July 9, 1949, M3413. *Labette County:* 4 miles north of Chetopa, creek bank, July 2, 1948, M1620. *Leavenworth County:* 5 miles southwest of Leavenworth, moist sandstone ledge, July 27, 1947, M1078. *Lincoln County:* 10 miles southeast of Lincoln, moist sandstone ledge, September 4, 1950, M4651. *Montgomery County:* 3 miles southwest of Elk City, moist sandstone rocks, and cattle trail through oak woods, July 1, 1947, M1068; September 1, 1948, M2385; September 22, 1951, M5221. *Washington County:* 1 mile west of Linn, on moist sandstone ledge in prairie ravine, August 23, 1947, M1086; August 10, 1948, M2055; 2 miles west of Linn, sandstone ledge on creek bank, August 22, 1952, M5712, M5715. *Wilson County:* 3 miles west of Neodesha, edge of pond in sandy prairie, June 30, 1947, M1605. *Woodson County:* 2 miles northwest of Yates Center, moist sandstone ledge, October 26, 1947, M1128; 8 miles south and 4 miles west of Yates Center, moist sandstone ledge, September 27, 1952, M6064. *Wyandotte County:* 5 miles northwest of Bonner Springs, on moist sandstone ledge, July 27, 1947, M1080.

4. *Notothylas orbicularis* (Schwein.) Sulliv. Widely distributed over the eastern half of the State. It has been found abundantly in a few prairies dominated by *Andropogon gerardi* and *Tripsacum dactyloides.* These areas include sandy soils and heavy loam soils. *N. orbicularis* is found in such areas in moist prairie swales. The species has been found twice on alluvial deposits along stream banks, once in an overgrazed pasture and once in a thicket of *Rubus argutus* in a clearing on an oak-hickory wooded hillside.

In one moist prairie swale *N. orbicularis* was found to average over 150 plants per meter quadrat in an area three acres in extent. It was not to be found on alluvial deposits in the drainage area below this prairie or in adjacent prairies with the equivalent habitat sites.

All collections of *N. orbicularis* seem to agree morphologically with published descriptions.

Distribution: *Cherokee County:* 5 miles east of Baxter Springs, alluvial deposit along Shoal Creek, August 30, 1948, M2356. *Clay County:* sandy bluestem prairie, August 16, 1948, M5070. *Douglas County:* 1 mile west of Pleasant Grove, bluestem prairie, July 17, 1941, M4985; July 24, 1951, M5001. *Johnson County:* near De Soto, overgrazed pasture, October 2, 1951, R. H. Thompson. *Leavenworth County:* 3 miles northeast of Tonganoxie, bluestem prairie, August 4, 1951, M5008. *Washington County:* 1 mile northeast of Linn, sandy bluestem prairie, August 21, 1951, M5074. *Miami County:* Miami County State Park, river bank, October 3, 1948, M2467. *Wilson County:* 1 mile northeast of Neodesha, sandy soil, *Rubus* thicket, clearing in oak woods, May 1, 1948, M1380.

SPHAEROCARPACEAE

5. *Sphaerocarpus michelii* Bellardi. Found on sandy soil near surfacing sandstone and in bare areas between clumps of *Andropogon gerardi* in sandy bluestem prairies. Plants are to be found in the spring, usually maturing in April in this region.

S. *michelii* is found most abundantly in a spring following a summer and fall of above average rainfall. In other years it is rare or absent. In this respect the species is like S. *texanus* and therefore is not a plant characteristic of the same habitat year after year.

One site, 5 miles west of Baldwin City, Douglas County, has been studied several years in succession. S. *michelii* and S. *texanus* are both found in this sandy, overgrazed prairie pasture. The abundance of plants to be found is directly correlated with rainfall and degree of removal of cover. A moist summer and fall with a simultaneous major reduction in grass cover has twice resulted in an abundance of *Sphaerocarpus* in this area. Meter quadrat studies revealed an average of 223 plants of S. *michelii* and S. *texanus* per meter quadrat over an area of two acres. S. *texanus* dominated at the rate of 12 to 1. In normal seasons and with more cover the abundance of *Sphaerocarpus* was reduced to an average of 18 plants per meter quadrat over the same area and S. *texanus* was dominant over S. *michelii* by a rate of over 30 to 1.

Sphaerocarpus michelii is not always easily separated from S. *texanus* in our area. It has never been found in pure colonies for S. *texanus* is invariably present and dominant in number of plants. S. *texanus,* however, has been found many times in pure colonies. Haynes (1910) described the chief differences separating S. *texanus* from S. *Sphaerocarpus* (S. *michelii*) to lie "in the more pointed fusiform-clavate rather than obovoid involucres, in the meshes of

the surface of spore tetrads being nearly twice as wide, and in the high ridges forming these meshes being sinuous or crenulate-margined or irregularly dissected, or occasionally rising into obtuse spines at the points of intersection, but never forming sharp needle-like spines as in S. *Sphaerocarpus*." Frye and Clark (1937-1947) report that the most reliable character separating S. *michelii* from S. *texanus* is the sharply spinose spore of the former. Frye and Clark also give the size of the spore tetrad as 80-110μ in diameter for S. *michelii* and 72-170μ in diameter for S. *texanus* while Haynes (1910) gives the size as 90-120μ for S. *michelii* and 72-171μ for S. *texanus*.

Studies on Kansas collections of these two species indicates clearly that the shape of the involucre is of no value in separating these taxa. The size of the spore tetrad is likewise of little use as the average size for both species is 108-110μ. S. *texanus* has the largest and also the smallest tetrads of the two and thus size alone is of little significance. The only constant character which can be used to separate the species is the size of the meshes on the spore tetrad. In S. *michelii* these range from 9-16.5μ while on S. *texanus* they range from 16-30μ with the average being 21μ.

S. *michelii* in its best expression has the ridges separating the spines low, their intersections with very acute or acicular spines. S. *texanus* characteristically has intersections spineless or with blunt spines. Kansas material, however, reveals a number of specimens in which these spine characters are intermediate and in which the ridges separating the meshes also intergrade. Haynes (1910) illustrates considerable variation of S. *texanus* spores. These variations are present in the species from our area. It seems possible, then, that some degree of hybridization has occurred but as yet this is only surmise.

S. *michelii* was first reported authentically from the United States by Frye and Clark (1937-1947) as occurring in Austin, Texas. Thompson (1948) reported the species from Shawnee County, Kansas. In addition to the Kansas records listed below the writer has collected the taxon from Arkansas, Missouri and Oklahoma.

Distribution: *Cherokee County:* 5 miles east of Baxter Springs, sandy soil, April 30, 1948, M1357. *Douglas County:* 5 miles west of Baldwin City, sandy bluestem prairie, April 18, 1948, M1343. *Elk County:* 10 miles north of Busby, sandy prairie, April 10, 1948, M1346. *Greenwood County:* 1 mile northeast Fall River, sandy prairie, April 10, 1948, M1347. *Leavenworth County:* 4

miles northeast Tonganoxie, sandy clearing in oak-hickory woods, May 7, 1948, M1407. *Montgomery County:* 3 miles south of Elk City, sandy soil over surfacing sandstone, April 4, 1942, R. H. Thompson. *Shawnee County:* Calhoun bluffs, north of Topeka, sandy soil, March, 1942, April, 1942, David Clark. *Wilson County:* 2 miles northeast of Neodesha, sandy soil in oak-hickory woods, April 10, 1948, M1345. *Woodson County:* 2 miles northwest of Yates Center, sandy soil in prairie pasture, April 9, 1948, M1344.

6. *Sphaerocarpus texanus* Aust. Widely distributed over the eastern half of the State. It occurs most abundantly on sandy bluestem prairie dominated by the big bluestem *Andropogon gerardi.* In these prairies it occurs in bare areas between the grass or around the base of the grass. Other habitats consist of trails or paths through sandy, or sandy clay-loam woods, alluvial deposits of streams, overgrazed pastures, and shallow soil over surfacing sandstone. It is rarely found on calcareous soils.

S. texanus is essentially a spring or early summer species and in this region produces mature spores in April and May. During the summer it is not to be found but in the fall it occurs from September to November on alluvial soils of stream banks, seepy areas and other very moist sites. It has never been found fruiting in the fall, a fact which may be due to the lack of development of male plants. A careful search, in the fall, has failed to reveal the presence of male plants at that time.

Morphological variations and other taxonomic points of *S. texanus* are discussed under *S. michelii* above.

The distribution of *S. texanus* in Kansas is undoubtedly greater than indicated below since many sterile plants have been seen but not collected. It almost certainly occurs in all counties of the eastern third of Kansas.

Distribution: *Chautauqua County:* 3 miles north of Elgin, sandy prairie pasture hilltop, April 5, 1952, M5348. *Cherokee County:* 5 miles east of Baxter Springs, rocky clay soil in clearing of oak-hickory woods, April 30, 1948, M1356. *Coffey County:* 2 miles southwest of LeRoy, sandy prairie pasture, April 9, 1948, M1238. *Cowley County:* 3 miles southeast of Arkansas City, sandy clay soil in open woods, April 11, 1948, M1301. *Douglas County:* 12 miles south of Lawrence, sandy prairie pasture, April 18, 1948, M1342; 5 miles northwest of Lawrence, moist soil in cattail-sedge marsh, May 14, 1948, M1420; 5 miles west of Baldwin City, sandy overgrazed

prairie meadow, March 25, 1948, M1165; 2 miles northeast of Lawrence, alluvial deposit on bank of Kansas River, June 12, 1952, M5605. *Elk County:* 10 miles north of Busby, sandy clay soil in prairie, April 10, 1948, M1288. *Ellsworth County:* 5 miles east of Carneiro, sandy soil in prairie, April 30, 1949, M2699. *Franklin County:* 1 mile northeast of Norwood, sandy prairie pasture, April 2, 1948, M1226. *Greenwood County:* 1 mile northeast of Fall River, sandy soil, clearing in oak woods, April 10, 1948, M1292. *Jefferson County:* 1 mile west of Medina, sandy clay pasture, April 2, 1948, M1232. *Labette County:* sandy soil, oak woods, April 10, 1948, M1268. *Montgomery County:* 3 miles south of Elk City, oak woods, April 4, 1942, R. H. Thompson. *Neosho County:* east of Chanute, sandy soil, February 14, 1945, R. H. Thompson; 2 miles northeast of Chanute, sandy soil, clearing in oak woods, April 9, 1948, M1259; 3 miles east of Chanute, sandy soil, May 12, 1951, R. H. Thompson. *Rice County:* 1 mile east of Geneseo, sandy prairie pasture, April 30, 1949, M2710. *Riley County:* near Manhattan, alluvial deposit, bank of Kansas River, April 30, 1949, Lucille Paslay. *Saline County:* 2 miles northwest of Brookville, sandy prairie pasture, April 30, 1949, M2691. *Shawnee County:* 7 miles southeast of Topeka, clay soil in severely overgrazed pasture, April 23, 1949, M2686. *Wilson County:* 1 mile northeast of Neodesha, sandy soil over surfacing sandstone, April 10, 1948, M1274. *Woodson County:* 2 miles northwest of Yates Center, sandy prairie, April 9, 1948, M1247; March 26, 1948, M2650. *Wyandotte County:* 1 mile northeast of Bonner Springs, sandy clearing in oak woods, May 15, 1948, M1442.

Lophoziaceae

7. *Lophozia bicrenata* (Schmid.) Dumort. This species is rare in Kansas having been found in two rather distant sites. In both places it occurred on the bare, dry crest of small sandy cliffs and is one of the most xerophytic of Kansas leafy Hepaticae.

A careful search of many suitable habitats for the species has been made without success. It agrees morphologically with published descriptions of the species.

Distribution: *Washington County:* 1 mile west of Linn, on dry sandy soil at crest of small cliff over sandstone outcrop, August 22, 1952, M5723. *Woodson County:* Woodson County State Park, exposed sandy soil at top of small cliff, March 26, 1949, M2643.

JUNGERMANNIACEAE

8. *Jamesoniella autumnalis* (D. C.) Steph. A species restricted to rather undisturbed oak-hickory wooded hillsides where it occurs on shaded sandstone outcrops or among mosses below decaying logs. It also is to be found on sandy clay soils and on small cliffs in the forest.

Due to its habitat requirements *J. autumnalis* occurs most frequently in northeastern Kansas where it is abundant in two sites. It has not been found in fruit and occurs as a rather large shade form which is light green in color except in dry seasons when it has a decided reddish tinge. It agrees well with published descriptions of the species otherwise.

Distribution: *Douglas County:* 2 miles north of Baldwin City, sandy clay soil, hillslope in mixed woods, March 30, 1952, M5325; 5 miles west of Baldwin City, shaded sandstone outcrop, April 26, 1952, M5441; 2 miles north of Baldwin, rotten log, July 19, 1952, M5660. *Leavenworth County:* 4 miles northeast of Tonganoxie, shaded sandstone cliff, June 1, 1952, M5663. *Woodson County:* 2 miles northwest of Yates Center, side of moist sandstone rocks, March 29, 1949, M2651; October 28, 1951, M5295; September 27, 1952, M6072.

9. *Jungermannia lanceolata* L. This species has been found but once in Kansas and then in the northeastern quarter in an area characterized by a flora with decided east and northeastern affinities.

A small colony of typical appearing *J. lanceolata* was found on sandy soil under an overhanging sandstone cliff. The surrounding areas, though carefully studied, failed to reveal additional specimens. The small colony, six inches long, has maintained itself and seems to be enlarging.

Specimens studied agree very well with published descriptions except that they seem regularly to produce gemmae.

Distribution: *Leavenworth County:* 4 miles northeast of Tonganoxie, sandy soil under an overhanging sandstone cliff, June 1, 1952, M5579.

10. *Plectocolea crenuliformis* (Aust.) Mitt. Rare in Kansas having been found but once. This site consisted of a shaded, moist, overhanging sandstone ledge on which the plants occurred as pure green mats but which were reddish-brown when the growth extended beyond the edge of the overhanging rock and were thus exposed.

The one collection of this species has the leaf margins swollen, oil-bodies 7.5μ in diameter and numbering five to ten per cell of the leaf. In these and other characters the specimens agree with descriptions of the species.

Distribution: *Woodson County:* 8 miles south and 4 miles west of Yates Center, underside of moist, shaded, overhanging sandstone ledge, September 27, 1952, M6062.

11. *Plectocolea fossombronioides* (Aust.) Mitt. Rare in Kansas but has been collected in five counties in the eastern third of the State. It has been found only on the sides of moist sandstone ledges along shaded creek banks where it forms extensive green mats often covering several square feet of rock. It seems to tolerate severe flooding and may prefer such conditions as it is most abundant on rock ledges inundated by high water.

Kansas specimens are clearly bisexual, have small barely evident trigones, purplish rhizoids and typically crenulate perianths. These features, characteristic of the species, serve to separate *P. fossombronioides* from other species of the genus in this area.

Distribution: *Chautauqua County:* 3 miles northeast of Sedan, moist sandstone ledge, March 26, 1948, M1218; April 12, 1950, M2400a. *Douglas County:* 5 miles west of Baldwin City, on moist sandstone rocks, August 26, 1948, M2312; April 22, 1950, M4233. *Elk County:* 10 miles north of Busby, sandstone rocks, July 27, 1948, M1915. *Leavenworth County:* 1 mile south of Kent, moist sandstone ledge, May 15, 1948, M1424; M1425. *Woodson County:* 2 miles northwest of Yates Center, moist sandstone ledge, April 9, 1948, M1241; September 24, 1949, M1949.

12. *Plectocolea hyalina* (Lyell) Mitt. This species has the general range and distribution of *P. fossombronioides.* It seems, however, to tolerate a wider range of habitat particularly in the ability to grow on drier sandstone rocks. It is also much more abundant than the above species with which it occurs in most sites studied.

Extensive mats of *P. hyalina* are reddish purple in early spring but later in the season, after unfolding of tree leaves, they become light green or nearly transparent. A characteristic of the species is the sheathing, orbicular bracts which seem to fuse with the perianth for a distance and from between which the perianth projects. This seems to vary in our collections from a rather loose to a tight ensheathing condition. The length of projection of the perianth seems also to vary. Rhizoids are reddish in color on drier sites and light yellowish-pink on more

moist places. Spore size varies from 13-17μ in diameter and elaters are usually 9-10μ in diameter.

The amount of morphological variation in the species indicates that a careful detailed study of the plant is desirable. This also has been indicated by Frye and Clark (1937-1947) and Schuster (1953).

Distribution: *Chautauqua County:* 1½ miles northeast of Sedan, on moist sandstone ledge, April 5, 1952, M5338. *Douglas County:* 5 miles west of Baldwin City, on moist sandstone rocks, August 26, 1948, M2313; November 7, 1948, M2575; October 15, 1949, M4149; October 15, 1951, M5252. *Leavenworth County:* 6 miles northeast of Tonganoxie, on moist sandstone ledge, August 24, 1948, M2264. *Montgomery County:* 3 miles southwest of Elk City, moist sandstone ledge and sandy soil below ledge, September 22, 1951, M5227. *Woodson County:* 2 miles northwest of Yates Center, moist sandy soil at base of cliff, October 28, 1951, M5277; 6 miles south and 4 miles west of Yates Center, moist sandstone rock, September 27, 1952, M6072.

PLAGIOCHILACEAE

13. *Plagiochila asplenioides* (L.) Dumort. Rare. Found once in the extreme southeast corner of the state in the small segment of Ozark flora which extends just into the State. It occurred on a steep, north facing, heavily wooded cliff. A colony some three inches long was found at the base of a large oak. The same colony has existed for the past several years but seems barely to survive. A thorough search of the surrounding areas failed to reveal more plants.

Distribution: *Cherokee County:* 5 miles east of Baxter Springs, base of large oak, north facing cliff, July 4, 1948, M1746.

HARPANTHACEAE

14. *Geocalyx graveolens* (Schrad.) Nees. Rare. Has been found in only three places in eastern Kansas. In each place the plants were growing under subcalcareous conditions usually in calcareous, sandy areas rich in humus.

The characteristic yellow-green opaque color seems to be very outstanding in Kansas material but the perigynia produced are few in number and are usually small and spherical. Even mature plants do not exhibit the prominent cylindrical perigynia found in the species in the eastern regions of this country. Otherwise the specimens agree favorably with descriptions of the species.

Distribution: *Cherokee County:* 5 miles east of Baxter Springs, sandy soil on wooded hillside, October 22, 1951, M5262. *Douglas County:* 2 miles north of Baldwin, sandy clay soil in rich woods, May 10, 1952, M5470. *Leavenworth County:* 4 miles northeast of Tonganoxie, calcareous sandstone, wooded bluff, June 1, 1952, M5573.

LOPHOCOLEACEAE

15. *Lophocolea minor* Nees. Rare. Found once in the Ozark area of extreme southeastern Kansas. It was growing among mosses on sandy soil below sandstone and limestone outcrops. A careful search of the area indicated that the species was not common but scattered among clumps of mosses such as *Leucobryum glaucum*. The plants produced numerous globular masses of gemmae and were typical of the species.

Distribution: *Cherokee County:* 5 miles east of Baxter Springs, growing in clumps of *Leucobryum glaucum*, May 9, 1953, M7202.

16. *Lophocolea bidentata* (L.) Dumort. Infrequent. Found on moist sandstone ledges and sandy-loam soil of hillsides in woodlands. It never is found in abundance but occurs among mosses on sandstone ledges or among mosses and debris on hillsides.

Kansas plants of this species are consistently sterile, light green in color and resemble the following listed species to such an extent that they may have been overlooked in the past.

Distribution: *Douglas County:* 2 miles north of Baldwin City, on decaying leaves, wooded hillside, March 30, 1952, M5323; on sandy soil among mosses, July 19, 1952, M5661; M5663. *Leavenworth County:* 4 miles northeast of Tonganoxie, moist sandstone ledge, June 1, 1952, M5574. *Montgomery County:* 3 miles southwest of Elk City, sandy soil among mosses, September 22, 1951, M5228. *Woodson County:* 2 miles northwest of Yates Center, on moist sandstone ledge, October 28, 1951, M5294.

17. *Lophocolea heterophylla* (Schrad.) Dumort. Widely scattered in eastern Kansas. Where found it is usually abundant but many suitable appearing habitats are without the species. It seems able to tolerate a large variety of habitats from moist rotting logs to dry sandy-clay soils of oak-wooded cliffs where it may cover the ground over large areas. It is strange that it is not more evenly distributed in eastern Kansas as it fruits freely and succeeds very well in some of our most common habitats.

The species shows all the usual morphological variations described and seems typical of the taxon as generally known.

Distribution: *Atchison County:* 1 mile south of Oak Mills, sandy-clay soil among mosses, July 14, 1948, M1803. *Chautauqua County:* 2 miles northeast of Sedan, sandy soil among mosses and lichens, August 10, 1950, M4395. *Cherokee County:* 5 miles east of Baxter Springs, among mosses on limestone ledge, April 26, 1947, M1020; on sandy-clay soil, July 31, 1948, M1924; August 30, 1948, M2354. *Douglas County:* 2 miles north of Baldwin, base of tree, on bark, June 20, 1948, M1588; clay soil, among mosses, June 4, 1951, M4855; sandy-loam bank, October 15, 1951, M5251; on rotten log, March 30, 1952, M5322; 5 miles west of Baldwin City, sandy soil and among *Leucobryum glaucum* and *Cladonia spp.*, April 26, 1952, M5439, M5469. *Johnson County*: 2½ miles south of Stanley, moist calcareous soil, wooded cliff, August 30, 1948, M2337. *Leavenworth County:* 4 miles northeast of Tonganoxie, on thin soil over sandstone ledge, June 1, 1952, M5568, M5576. *Linn County:* 3 miles north of Pleasanton, on sandy-clay soil, August 1, 1948, M1949. *Montgomery County:* 3 miles southwest of Elk City, sandy soil, ledge in oak woods, September 1, 1948, M2386; September 22, 1951, M5229. *Neosho County:* 2 miles east of Chanute, sandy soil, April 17, 1949, R. H. Thompson. *Shawnee County:* 5 miles east of Topeka, rotten log, April 23, 1949, M2677. *Wilson County:* 1 mile northeast of Neodesha, on sandy soil among mosses and lichens, August 31, 1948, M2377. *Woodson County:* 1 mile northwest of Yates Center, sandy bank, October 20, 1951, M5294.

18. *Chiloscyphus pallescens* (Ehrh.) Dumort. Rare. One site known for the species in the State. At this site the plant is rather common along a sandstone cliff which is about a mile long. Here the plant is found on the sides of moist sandstone ledges and on sandy soil below the ledges.

Distribution: *Leavenworth County:* 4 miles northeast of Tonganoxie, on side of sandstone ledge, October 29, 1948, M2564; on sandy soil below sandstone ledge, June 1, 1952, M5567.

19. *Chiloscyphus pallescens* (Ehrh.) Dumort var. *fragilis* (Roth) K. Müller. Rare. Found only with the species mentioned above but in more moist situations. The variety differs from the species in the larger cells of the leaves, darker color and requirement for a more moist habitat. It seems doubtful whether var. *fragilis* merits taxonomic status but needs more study.

Distribution: *Leavenworth County:* 4 miles northeast of Tonganoxie, on side of very moist sandstone ledge, June 11, 1948, M1579; June 1, 1952, M5569.

Scapaniaceae

20. *Diplophyllum apiculatum* (Evs.) Steph. Rare. Found once in the Ozark area of the extreme southeast corner of the state. It was growing on a rocky, clay-loam wooded hillslope. Plants were not common and occurred only in mats of *Scapania nemorosa.*

Distribution: *Cherokee County:* 5 miles east of Baxter Springs, rocky, clay-loam hillside, among *Scapania nemorosa,* April 30, 1948, M1361a.

21. *Scapania irrigua* (Nees) Dumort. Rare. Characteristic specimens of the species were found once on a very moist depression on the side of a sandstone cliff. The plants were not numerous and occurred only in the depression which was kept moist by a small spring above it.

Distribution: *Leavenworth County:* 4 miles northeast of Tonganoxie, depression in sandstone cliff, May 7, 1948, M1390.

22. *Scapania nemorosa* (L) Dumort. Abundant in sandstone areas of eastern Kansas much less common on clay-loam hillsides and absent from all but very moist calcareous sites. Where found, S. *nemorosa* may form large mats on moist sandstone ledges or be generally distributed on soil, among mosses, or on sandy banks. Elsewhere the species forms isolated colonies among mosses.

In our area S. *nemorosa* usually forms abundant one-celled, reddish or reddish-brown gemmae. However, it may often produce few gemmae and these may be light green in color or scarcely pigmented. The expression of the denticulate leaf margin is highly variable. In some collections the leaves are sharply spinous-dentate and in others this is barely evident. This may be correlated with amount of moisture and exposure though study fails to verify this conclusively. The latter plants are difficult to separate from S. *undulata* due to these variable conditions. S. *undulata* occurs also with *nemorosa* though it is never as common or abundant. S. *undulata,* of our area, characteristically has 2-celled, light green gemmae, a leaf margin with a distinct border of several rows of thick walled cells, and ventral lobes of leaf rather indistinctly decurrent. S. *nemorosa* has leaves with all cells collenchymatous, the gemmae are one celled, and reddish-brown, and the leaf lobe is distinctly decurrent.

Distribution: *Chautauqua County:* 3 miles northeast of Sedan, sandy soil, March 26, 1948, M1217; May 1, 1948, M1369; July 8, 1949, M3382; April 5, 1952, M5337. *Cherokee County:* 5 miles east of Baxter Springs, rocky wooded hillside, April 30, 1948, M1361. *Douglas County:* 5 miles west of Baldwin City, on

moist sandy bank, October 18, 1947, M1144; November 7, 1948, M2574; June 18, 1949, M3106; September 16, 1950, M4672; April 26, 1952, M5441. *Franklin County:* 4 miles southwest of Ottawa, moist sandy bank, June 18, 1949, M3098. *Greenwood County:* 6 miles north of Fall River, on sandstone ledge, July 27, 1948, M1907, M1908; 1 mile east of Fall River, sandy bank, April 13, 1949 M2671; July 8, 1949, M3412. *Leavenworth County:* 4 miles northeast of Tonganoxie, moist sandstone ledge, May 7, 1948, M1400. *Montgomery County:* 6 miles south of Elk City, moist sandy bank, March 26, 1948, M1186; 3 miles southwest of Elk City, sandy bank, September 1, 1948, M2389; September 22, 1951, M5226. *Woodson County:* 2 miles northwest of Yates Center, moist sandstone ledge, June 19, 1949, M3197; October 28, 1951, M5285.

23. *Scapania undulata* (L.) Dumort. Rare. Collections of this species have been made several times in two similar habitats. These consist of wooded sandstone cliffs with northern exposure and are usually very moist. All plants were found among mosses such as *Atrichum angustatum, Dicranum scoparium, Entodon seductrix, Pohlia nutans* and *Leucobryum glaucum.* These mosses, with *S. undulata* and often *S. nemorosa,* form a dense mat over moist sandy banks.

Distribution: *Douglas County:* 2 miles north of Baldwin City, sandy bank, July 19, 1952, M5659. *Leavenworth County:* 4 miles northeast of Tonganoxie, sandy moss covered cliffs, August 24, 1948, M2261; M2265; June 1, 1952, M5565.

CEPHALOZIELLACEAE

24. *Cephaloziella byssacea* (Roth) Warnstf. Rare. Found on the crests of moist sandy ledges which are only partially shaded. It is usually intermingled with various mosses and species of *Cladonia.* This species undoubtedly has a greater distribution than is indicated below.

Distribution: *Greenwood County:* 6 miles north of Fall River, crest of moist, partially shaded, sandy cliff, July 27, 1948, M1913. *Montgomery County:* 6 miles south of Elk City, crest of moist sandy cliff, March 26, 1948, M1187.

25. *Cephaloziella hampeana* (Nees) Schiffn. Rare. Found admixed with other hepatics and mosses on moist sandstone ledges and seepy sandy banks particularly where limestone occurs associated with the above habitats.

Distribution: *Chautauqua County:* 2 miles northeast of Sedan, sandy soil on seepy bank, April 5, 1952, M5343. *Douglas County:* 2 miles north of Baldwin City, sandy subcalcareous moist bank, July 19, 1952, M5666. *Leavenworth County:* 4 miles northeast of Tonganoxie, sandy subcalcareous bank, June 1, 1952, M5575.

26. *Cephaloziella rubella* (Nees) Douin. Widely distributed in the eastern half of the State and abundant in many of the sites. It is a distinct xerophyte and occurs on denuded crests of sandstone cliffs which are dry through most of the year or which dry quickly after rainfall. It also occurs in sandy or sandy-clay, oak-hickory forest where it is found on denuded or eroded banks, base of trees or along the edge of road cuts and trails. It occasionally is to be found on the sides of moist sandstone ledges.

On some of the dry crests of sandstone ledges this is the only hepatic to be found and often forms reddish-brown or blackish mats which may cover several square feet.

C. rubella seems to be quite variable even in the same colony. A little colony of the species has been collected which were mostly autoecious. Such plants would be referred to *Cephaloziella rubella* (Nees) Douin var. *bifida* Lindb.; however, the character is not constant and a colony usually shows some autoecious plants though mostly paroecious plants are to be found. This condition is apparently not related to moisture or exposure factors.

In some of the more moist sites and particularly those in which more humus is found one encounters plants which might be referred to *C. rubella* var. *sullivantii* (Aust.) K. Müller. They have leaf cells 9-12μ wide and walls which are a little thinner than in *C. rubella*. Also the involucral bracts form a ring of 7-9 lobes and are dentate on the margin while in *C. rubella* the ring has 5-6 lobes which are only slightly dentate to entire. However, none of the specimens show the minute underleaves of var. *sullivanti* and since the other characters seem to be quite variable it seems best not to segregate specimens from Kansas into varieties. If such segregation were attempted it would mean that var. *rubella*, var. *bifida* and var. *sullivantii* would all occur in the same colony.

Distribution: *Cherokee County:* 5 miles east of Baxter Springs, moist sandy-clay soil, crest of cliff, October 22, 1951, M5270. *Douglas County:* 12 miles south of Lawrence, dry sandy crest of ledge, October 13, 1951, M5243, M5250; 5 miles west of Baldwin City, ledge above sandstone outcrop, March 12, 1952, M5321, M5324;

April 26, 1952, M5432; 4 miles north and 5 miles east of Baldwin City, edge of road cut in sandy oak woods, May 3, 1952, M5460. *Ellsworth County:* 2 miles north and 4½ miles west of Langley, bare sandy soil, crest of cliff, May 3, 1952, M5444, M5451. *Leavenworth County:* 4 miles northeast of Tonganoxie, sandy bank in oak-hickory woods, June 1, 1952, M5564, M5565. *Montgomery County:* 3 miles southwest of Elk City, on side of dry limestone ledge, September 22, 1951, M5224, M5225, M5226. *Washington County:* 2 miles west of Linn, dry sandy soil over surfacing sandstone, August 22, 1952, M5717, M5721. *Woodson County:* 2 miles northwest of Yates Center, side of dry ledge, October 28, 1951, M5276, M5286; 8 miles south and 4 miles west of Yates Center, side of sandstone rock, September 27, 1952, M6066.

CEPHALOZIACEAE

27. *Cephalozia bicuspidata* (L.) Dumort. Rare. Found on moist sandstone ledges usually on the under side of overhanging rocks which are kept moist by seepage. It was discovered once among mosses on a sandy-clay hillside in oak-hickory forest.

Distribution: *Douglas County:* 2 miles north of Baldwin City, sandy-clay soil, among mosses, July 19, 1952, M5662. *Woodson County:* Lake Fegan, Woodson County State Park, on underside of moist, overhanging sandstone ledge, March 26, 1949, M2644, M2645; September 24, 1949, M4131.

28. *Cephalozia catenulata* (Huben.) Spr. Rare. This species was found once on the side of a moist, sandy-clay bank in an oak-hickory woods. The plants formed an extensive mat on the shaded portions of these banks.

Distribution: *Woodson County:* Lake Fegan, Woodson County State Park, sandy-clay bank in oak-hickory woods, March 26, 1949, M2657.

29. *Cephalozia connivens* (Dicks) Lindb. Rare. Found once on a north-facing sandstone cliff where the plants occurred on sandy soil among mosses and lichens. A careful search showed the plant to be rare in the area.

Distribution: *Leavenworth County:* 4 miles northeast of Tonganoxie, north-facing sandstone bluff, on sandy soil, June 1, 1952, M5577.

30. *Cephalozia media* Lindb. Rare. Collected from a moist sandy bank and again from the side of a nearby sandstone ledge. The plants occurred in considerable quantity on these two sites.

Distribution: *Woodson County:* Lake Fegan, Woodson County State Park, on moist sandy-clay bank, March 26, 1949, M2642; on side of moist sandstone rocks, September 24, 1949, M4132.

CALYPOGEIACEAE

31. *Calypogeia meylanii* Buch. Rare. Found once on the side of a sandstone ledge on a north-facing, oak-hickory wooded bluff. The plants were very rare in the area.

Distribution: *Leavenworth County:* 4 miles northeast of Tonganoxie, on moist sandstone ledge, October 3, 1953, M7521.

32. *Calypogeia muelleriana* (Schiffn.) K. Müller. Rare. Found once on the side of a moist sandstone ledge in a deep ravine running through an oak wooded area. The plants were rather generally distributed along the ledges in the ravine.

Specimens of this species in our collections have colorless oil bodies and seem close to *C. meylanii* in many respects; but after a detailed study it was finally decided to recognize our specimens as indicated. However, a detailed study of the species in this country seems to be necessary.

Distribution: *Woodson County:* 8 miles south and 4 miles west of Yates Center, on moist sandstone ledges, September 27, 1952, M6063, M6065, M6073, M6074, M6077, M6078.

33. *Calypogeia trichomanis* (L.) Corda. Rare. This species occurs in the same general habitat as do the previous listed species of the genus. However, it seems to be more prevalent and perhaps a little more dispersed. The blue-colored, oil bodies in leaf cells separate this species readily from all closely related forms.

Distribution: *Leavenworth County:* 4 miles northeast of Tonganoxie, sandy ledge, June 1, 1952, M5571, M5572, M5580. *Woodson County:* Lake Fegan, Woodson County State Park, moist sandstone ledge, September 24, 1949, M4133.

PORELLACEAE

34. *Porella pinnata* L. Scattered in the southeastern quarter of the State. The species is found in two very different types of habitat. One is on the bark of trees or on rocks at water level of creeks in the extreme southeast corner of the State. In such places the plants may be partially submerged. Usually they are found between water level and flood level. The second habitat is on dry limestone outcrops on cliffs. This is not a common habitat but plants have been found in two different places on these very

dry outcrops. In the latter sites *P. pinnata* is associated with *P. platyphylla* and *P. platyphylloidea.*

Morphologically *P. pinnata* on bark at water level and on dry limestone outcrops exhibit slight differences which one expects in plants occupying such diverse habitats. A careful study of the species over its entire range is, perhaps, desirable.

Distribution: *Anderson County:* 5 miles south of Garnett, on dry limestone outcrop, October 8, 1948, M2485. *Bourbon County:* 2 miles south of Uniontown, on dry limestone outcrops, October 9, 1948, M2515. *Cherokee County:* 5 miles east of Baxter Springs, on rocks, bank of Shoal Creek, July 5, 1948, M1747; bark of birch, July 31, 1948, M1946; bark of sycamore, October 22, 1951, M5255.

35. *Porella platyphylla* (L.) Lindb. Scattered in the eastern third of the State particularly in the southern half. In some places the species forms large mats on limestone outcrops. Abundance depends upon moisture and shade. Dry exposed sites are without the species and it becomes more common and abundant as moisture increases.

In Kansas *P. platyphylla* occurs in exactly the same type of habitat as does *P. platyphylloidea* though they are seldom found together. Schuster (1953) says that *P. platyphylla* is by far the less frequent species in North America. However, in Kansas, we find *P. platyphylloidea* only a little more common than *P. platyphylla.*

Morphologically the two species are quite similar and Frye and Clark (1937-1947) reduced *P. platyphylloidea* to a variety of *P. platyphylla.* Difficulties are met with in Kansas material in that neither of the taxa have been found fruiting. This is apparently true elsewhere resulting in incomplete studies being made on one of the common species. Our determinations have been made on mature vegetative plants. In our experience it is only the juvenile plants or young shoots that seem to intergrade. Our findings agree very closely with those given by Schuster (1953) on the complex.

Distribution: *Allen County:* 1 mile south of Humboldt, on dry limestone ledge, July 7, 1949, M3338. *Bourbon County:* 1 mile south of Uniontown, on limestone outcrop, July 7, 1949, M3347. *Cowley County:* 2 miles southeast of Arkansas City, on limestone ledge, September 2, 1950, M4646. *Doniphan County:* 2 miles northwest of Iowa Point, limestone outcrop, August 2, 1948, M1972. *Greenwood County:* 4 miles west of Fall River, limestone ledge,

April 13, 1949, M2673. *Johnson County:* 5 miles south of Stanley, on limestone outcrop, August 30, 1948, M2330; August 3, 1950, M4388. *Miami County:* Murray Lake, limestone rocks, October 9, 1948, M2530. *Montgomery County:* 4 miles east of Elk City, on limestone outcrop, April 12, 1949, M2667. *Wilson County:* 3 miles southwest of Neodesha, on limestone ledge, April 13, 1949, M2668.

36. *Porella platyphylloidea* (Schwein.) Lindb. Distributed over the eastern third of Kansas. Its habitat requirements are so similar to those of *P. platyphylla* that no further mention of the subject need be given. Morphological information of this species is likewise considered with *P. platyphylla.*

Distribution: *Anderson County:* 2 miles south of Garnett, on limestone outcrop, April 13, 1949, M2674. *Bourbon County:* 2 miles south of Uniontown, moist limestone ledge, July 5, 1948, M1775. *Chautauqua County:* 2 miles southwest of Sedan, on limestone outcrop, April 12, 1949, M2666. *Cherokee County:* 5 miles west of Baxter Springs, on limestone rocks, April 25, 1942, R. H. Thompson; on limestone outcrop, April 12, 1949, M2662. *Douglas County:* 2 miles north of Clinton, on limestone ledge, September 10, 1948, M2443. *Franklin County:* 1 mile southeast of Ottawa, on limestone outcrop, June 28, 1949, M3312. *Leavenworth County:* 5 miles northwest of Leavenworth, on limestone outcrop, September 7, 1948, M2420; 2 miles north of Leavenworth, on limestone outcrop, October 29, 1948, M2565. *Linn County:* 2 miles north of Trading Post, on limestone outcrop, April 11, 1949, M2659. *Montgomery County:* 8 miles west of Sycamore, on limestone outcrop, September 1, 1948, M2406; March 30, 1952, M5327.

Lejeuneaceae

37. *Cololejeunea biddlecomiae* (Aust.) Evs. Rare. Found in three mesic woodlands in eastern Kansas. In each case the plants were growing on the bark of trees at the base of the trunk and in shaded rather moist conditions. Two of these sites were on calcareous cliffs and the third was in a sandstone canyon.

Distribution: *Cherokee County:* 5 miles east of Baxter Springs, limestone cliff, on bark at base of hackberry tree, Oct. 22, 1951, M5259. *Leavenworth County:* north edge of Military Reservation, limestone bluff, bark of burr oak, Nov. 28, 1948, M2619. *Woodson County:* 8 miles south and 4 miles west of Yates Center, sandstone canyon, bark of *Asimina triloba,* September 27, 1952, M6067.

FRULLANIACEAE

38. *Frullania asagrayana* Mont. Rare. Found but once in the state and that in a mesic forest on the bluffs of the Missouri River. In this local forest, plants of *F. asagrayana* were found on limestone ledges which are dry most of the year but have a period of heavy seepage over them in early spring.

Distribution: *Leavenworth County:* 2 miles north of Leavenworth, on limestone ledge, October 29, 1948, M2566.

39. *Frullania brittoniae* Evs. Common in the Ozark area of southeastern Kansas but known from only one station outside of that restricted habitat. This species has been found only on the bark of trees.

Distribution: *Cherokee County:* 5 miles east of Baxter Springs, bark of *Quercus alba,* July 31, 1948, M1930, M1932; October 22, 1951, M5257; bark of *Betula nigra,* M5269. *Woodson County:* 2 miles northwest of Yates Center, bark of *Quercus macrocarpa,* October 28, 1951, M5288.

40. *Frullania eboracensis* Gottsche. To be found in nearly all mixed forests in the eastern fourth of the state. It is limited exclusively to occurrence on the bark of trees especially oak. In general a lowland or flood plain forest supports an abundance of this species and it becomes less common as drier forest conditions are reached. The species seems also to be more common and abundant on forests of calcareous soils than in those on sandy soils.

In most of our material there is a decided tendency for the plants to have caducous leaves and thus to appear leafless in late summer or early spring. Otherwise the species exhibits the morphological structures described for the taxon. In extreme southeastern Kansas *F. eboracensis* is often difficult to separate from *F. brittoniae* especially when sterile or juvenile; however, they can usually be separated on the underleaf, the upper halves of which, in *F. brittoniae,* are usually dentate or dentate-crenate and are entire or bear one tooth in *F. eboracensis.* The characters of the inflated lobules as given by Schuster (1953) to separate the two species seem to intergrade too much to be of value in our area.

Distribution: *Atchison County:* 1 mile east of Potter, bark of *Quercus macrocarpa,* June 2, 1949, M2816. *Brown County:* 5 miles west of Hiawatha, bark of *Quercus macrocarpa,* June 3, 1949, M2826. *Chautauqua County:* 2 miles northeast of Sedan, bark of *Quercus stellata,* April 12, 1950, M4196. *Cherokee County:* 5 miles east of Baxter Springs, bark of *Quercus alba,* July 3, 1948, M1627,

M1628; bark of fallen oak, July 4, 1948, M1745; bark of *Quercus rubra,* October 9, 1948, M2522; bark of *Betula nigra,* October 22, 1951, M5254. *Coffey County:* 4 miles west of Waverly, bark of *Quercus velutina,* June 27, 1948, M1601. *Cowley County:* 2 miles southeast of Arkansas City, bark of *Quercus macrocarpa,* September 2, 1950, M4645. *Douglas County:* 2 miles north of Baldwin City, bark of *Quercus alba,* May 29, 1948, M1516; 4 miles northwest of Baldwin City, bark of *Quercus macrocarpa,* August 26, 1948, M2303; 5 miles west of Baldwin City, bark of *Quercus velutina,* December 28, 1948, M2620; bark of *Ulmus rubra,* September 18, 1949, M4077; bark of *Platanus occidentalis,* July 19, 1952, M5658. *Labette County:* 4 miles northwest of Chetopa, bark of *Ulmus americana,* July 2, 1948, M1612. *Leavenworth County:* 1 mile south of Kent, bark of *Quercus macrocarpa,* June 11, 1948, M1581; bark of *Quercus muehlenbergii,* June 11, 1948, M1582. *Miami County:* 3 miles east of Fontana, bark of *Quercus macrocarpa,* October 10, 1948, M2531; bark of *Quercus muehlenbergii,* October 8, 1950, M4683; bark of *Carya illinoensis,* October 8, 1950, M4686; bark of *Ulmus rubra,* October 27, 1950, M4690; bark of *Fraxinus lanceolata,* October 27, 1950, M4691. *Neosho County:* 2 miles east of Chanute, bark of oaks, April 17, 1949, R. H. Thompson. *Shawnee County:* 5 miles east of Topeka, bark of *Quercus macrocarpa* and *Ulmus americana,* April 23, 1949, M2675. *Sedgwick County:* 2 miles northwest of Wichita, bark of *Ulmus americana,* September 3, 1950, M4648. *Woodson County:* 2 miles northwest of Yates Center, bark of *Quercus velutina, Q. stellata, Q. marilandica* and *Celtis occidentalis,* October 28, 1951, M5287; bark of *Quercus macrocarpa,* September 27, 1952, M6081.

41. *Frullania inflata* Gottsche. This species is without doubt the most abundant hepatic in the state. It is found in all of the eastern half where it occurs on the bark of many trees, moist limestone cliffs and often on the sides of sandstone ledges. It is most abundant in the elm floodplain forests along creeks and rivers and only slightly less frequent in the mixed forests on river bluffs and hillsides. It extends westward into the mid-grass prairies as far as *Quercus macrocarpa* can be found along the streams of that area.

Frullania inflata is highly variable in our area. It fruits abundantly and mature capsules are to be found from January to July in seasons following average or above average rainfall but never fruits after a very dry year. The most variable structure seems to be the lobules. These are characteristically inflated but explanate

or lingulate lobes are nearly always present on young parts. The drier the habitat the more frequent the inflated lobule while the more moist the habitat, such as seepy rock ledges, the more abundant are the lingulate lobules. The size of the lobule varies from ¼-½ of the size of the dorsal lobe and sometimes almost equals the dorsal lobe in size. Such plants from Kansas have been named by some, *Frullania oakesiana* Aust., a northern species, not yet found in Kansas.

Distribution: *Allen County:* 1 mile south of Humboldt, on dry limestone ledge, July 7, 1949, M3337. *Anderson County:* 3 miles north of Garnett, on bark of *Ulmus rubra,* August 1, 1948, M1960; 2 miles south of Garnett, on *Ulmus rubra,* June 4, 1951, M4878. *Bourbon County:* 2 miles south of Uniontown, bark of *Quercus rubra,* October 8, 1948, M2519; 1 mile south of Uniontown, on limestone outcrop, July 7, 1949, M3346; October 22, 1951, M5271. *Chase County:* 1 mile south of Strong City, bark of *Quercus macrocarpa,* November 27, 1948, M2602. *Butler County:* 5 miles north of El Dorado, bark of *Juglans nigra,* August 18, 1953, M2251. *Chautauqua County:* 2 miles northeast of Sedan, on bark of *Quercus stellata,* April 5, 1953, M5334. *Cherokee County:* 5 miles east of Baxter Springs, limestone outcrop, July 3, 1948, M1649; July 7, 1949, M3363; bark of *Quercus macrocarpa,* October 22, 1951, M5267; bark of *Celtis occidentalis,* July 8, 1952, M5650; bark of *Quercus alba,* May 9, 1953, M7200. *Cowley County:* 2 miles southeast of Arkansas City, bark of *Quercus macrocarpa,* September 2, 1950, M4644. *Crawford County:* Crawford County State Park, bark of *Ulmus rubra,* July 5, 1948, M1753; October 9, 1948, M2529. *Dickinson County:* 6 miles northwest of Herington, bark of *Quercus macrocarpa,* June 24, 1950, M4357. *Doniphan County:* 1 mile northwest of Iowa Point, bark of *Ulmus rubra,* August 2, 1948, M1965. *Douglas County:* 6 miles northwest of Lawrence, bark of *Ulmus americana,* August 26, 1948, M2275; Lone Star Lake, bark of *Quercus macrocarpa,* August 28, 1948, M2320; 2 miles northwest of Clinton, bark of *Quercus muehlenbergii,* September 10, 1948, M2447; 4 miles northwest of Lawrence, bark of *Quercus muehlenbergii,* August 19, 1950, M4483; 2 miles east of Lecompton, bark of elm, July 13, 1949, R. H. Thompson; 2 miles north of Baldwin City, bark of *Quercus velutina,* April 25, 1953, M7197. *Franklin County:* 4 miles east of Princeton, bark of *Quercus macrocarpa,* May 29, 1949, M2763; 2 miles south of Lane, on dry limestone rocks, June 5, 1952, M5589. *Harvey County:* 1 mile east of Annelly, bark of *Quercus macrocarpa,* August 19, 1948,

M2254. *Jefferson County:* 1 mile north of Valley Falls, bark of *Quercus macrocarpa,* January 22, 1953, M7000. *Jewell County:* 4 miles north of Burr Oak, on bark of *Quercus macrocarpa,* September 5, 1950, M4653. *Johnson County:* 5 miles south of Stanley, bark of *Quercus velutina,* August 30, 1948, M2335; on moist limestone rocks, August 3, 1950, M4387. *Labette County:* 4 miles northwest of Chetopa, bark of *Betula nigra,* July 2, 1948, M1616. *Leavenworth County:* 1 mile south of Kent, bark of *Quercus macrocarpa,* June 11, 1948, M1580. *Linn County:* 3 miles north of Pleasanton, on limestone outcrop, August 1, 1948, M1950. *Lyon County:* 4 miles southwest of Emporia, bark of *Quercus macrocarpa,* June 26, 1948, M1592. *Marion County:* 1 mile south of Florence, bark of *Ulmus americana,* November 27, 1948, M2613. *Marshall County:* 8 miles north of Frankfort, bark of *Quercus macrocarpa,* August 9, 1948, M2032. *McPherson County:* 6 miles north of Conway, bark of *Ulmus rubra,* July 24, 1948, M1819. *Miami County:* 2 miles southeast of Fontana, bark of *Quercus macrocarpa,* November 12, 1948, M2580. *Montgomery County:* 8 miles west of Sycamore, on limestone outcrop, September 1, 1948, M2307; bark of *Quercus macrocarpa,* September 1, 1948, M2408 *Morris County:* 2 miles north of Council Grove, bark of *Ulmus americana,* November 27, 1948, M2618. *Nemaha County:* Nemaha County State Park, bark of *Quercus macrocarpa,* August 9, 1948, M2013. *Riley County:* 4 miles south of Manhattan, on bark of *Quercus macrocarpa,* June 24, 1953, M7480. *Sedgwick County:* 2 miles north of Wichita, bark of *Ulmus americana,* September 3, 1950, M4647. *Shawnee County:* 5 miles east of Topeka, bark of trees, April 23, 1949, M2681. *Washington County:* 2 miles west of Linn, bark of *Quercus macrocarpa,* August 22, 1953, M5714. *Wabaunsee County:* 5 miles west of Eskridge, bark of *Ulmus americana,* July 25, 1948, M1857. *Wilson County:* 1 mile northeast of Neodesha, bark of *Quercus macrocarpa,* August 31, 1948, M2379; 1 mile east of Altoona, bark of *Quercus velutina,* August 29, 1952, M5726. *Woodson County:* 2 miles northwest of Yates Center, bark of *Quercus velutina,* July 5, 1948, M1792; March 26, 1949, M2640; 8 miles south and 4 miles west of Yates Center, bark of *Quercus stellata,* September 27, 1952, M6082, M6070.

42. *Frullania kunzei* Lehm. and Lindenb. Rare. Known from one collection from the Ozark area of the extreme southeastern corner of the State. Here it was found on the bark of *Quercus alba.* Our collection probably represents the most northwestern record of the species.

Distribution: *Cherokee County:* 5 miles east of Baxter Springs, on bark of *Quercus alba,* October 22, 1951, M5256.

43. *Frullania riparia* Hampe. Rather frequent in the eastern half of Kansas where it is found on limestone ledges and on tree bark in forests occurring on limestone hillsides. It seems to be entirely absent from sandstone areas except for an occasional occurence on bark of *Quercus macrocarpa.* Kansas specimens of this species are often very difficult to separate from *Frullania squarrosa.* In seasons of average or above average rainfall most material seems easily referable to *F. riparia.* However, on very dry sites and during dry years such as in 1952-53 most plants seem to fall within the range of *F. squarrosa.* The possibility that *F. squarrosa* is a xeric extreme and *F. riparia* a mesic extreme has been suggested by Schuster (1953), and Kansas material seems to show that this may be the case. In Kansas *F. riparia,* in mesic conditions, shows rather small trigones and has no intermediate thickenings, the lobules, being mostly explanate or ligulate, the leaves rather lax and distant to underleaves. The color is usually green or reddish-green. In xeric conditions *F. riparia* is reddish-brown or copperish in color, the leaves somewhat squarrose, having large trigones, and the underleaves large. Often the leaves are also imbricated. The only character in these xeric plants which is absent, but present in *F. squarrosa,* is the intermediate thickening between trigones. None of our plants of the two extremes have been found with mature capsules.

The above facts indicate, as did the findings of Schuster (1953), that a careful detailed study of *F. riparia* over its range is needed. Furthermore, careful ecological data should be taken along with specimens. It seems possible that the finding of mature capsules of *F. riparia* might help solve the problem.

Distribution: *Allen County:* 2 miles south of Iola, bark of *Quercus macrocarpa,* July 5, 1948, M1789. *Bourbon County:* 5 miles north of Hepler, May 30, 1949, L. J. Gier, 1864; 2 miles south of Uniontown, on limestone rocks, July 5, 1948, M1774. *Chautauqua County:* 2 miles southwest of Sedan, on limestone rocks, April 12, 1949, M2664; bark of *Quercus macrocarpa,* April 12, 1949, M2665; 1 mile north of Sedan, on bark of *Quercus stellata,* April 5, 1952, M5335. *Cherokee County:* 5 miles east of Baxter Springs, on bark of *Quercus alba,* July 3, 1948, M1655; on limestone rocks, April 12, 1949, M2663; October 22, 1951, M5260; bark of *Quercus macrocarpa,* October 22, 1953, M5261. *Douglas County:* Lone Star Lake, bark of *Ulmus rubra,* May 15, 1948, M1445; 2 miles north of Baldwin

City, on bark of *Quercus alba,* May 29, 1948, M1517; 2 miles northwest of Clinton, limestone ledge, September 10, 1948, M2444; 1 mile west of Pleasant Grove, tree bark, May 8, 1949, R. H. Thompson; 2 miles north of Baldwin City, on bark of *Ostrya virginiana,* December 8, 1951, M5295. *Jefferson County:* 2 miles west and 5 miles south of McLouth, bark of *Quercus macrocarpa,* October 15, 1949, M4155. *Johnson County:* 2½ miles south of Stanley, on limestone outcrop, August 3, 1950, M4387; April 11, 1949, M2656. *Linn County:* 2 miles north of Trading Post, on limestone outcrop, April 11, 1949, M2660. *Miami County:* Miami County State Park, on bark of *Quercus macrocarpa,* October 3, 1948, M2480; 2 miles southeast of Fontana, bark of *Quercus muehlenbergii,* November 12, 1948, M2581; bark of *Quercus velutina,* October 17, 1949, M4159, M4160. *Montgomery County:* 8 miles west of Sycamore, on side of limestone outcrop, September 1, 1948, M2409; April 5, 1952, M5328. *Osage County:* 7 miles south of Overbrook, bark of *Celtis laevigata,* February 22, 1953, R. H. Thompson. *Shawnee County:* 5 miles east of Topeka, bark of *Quercus macrocarpa,* April 23, 1949, M2682. *Wabaunsee County:* 6 miles northwest of Pasco, bark of *Quercus macrocarpa,* June 25, 1950, M4364. *Wilson County:* 3 miles west of Neodesha, bark of *Quercus macrocarpa,* April 13, 1949, M2660; 1 mile east of Altoona, bark of *Carya ovata,* August 29, 1952, M5727.

44. *Frullania squarrosa* (R., Bl. N.) Dumort. Two collections of *Frullania* have been definitely assigned to this taxon. In both cases the specimens match perfectly the descriptions given for the species and in addition were fruiting. In Kansas the species is difficult to separate from *Frullania riparia* and the subject is discussed under *F. riparia.*

Distribution: *Douglas County:* 1 mile northwest of Clinton, on limestone ledge, September 26, 1948, M2464. *Leavenworth County:* 2 miles north of Leavenworth, bark of *Quercus macrocarpa,* October 29, 1948, M2567.

FOSSOMBRONIACEAE

45. *Fossombronia brasiliensis* Steph. Uncommon. A species found on moist sandy soil in bluestem prairie, over surfacing sandstone, sides of moist sandstone ledges and along sandy paths or roadside cuts. It prefers exposed or recently eroded sites. Where found it is usually abundant, though it may be present in an area one season and absent in the next. It, like *Sphaerocarpus texanus,*

is most abundant in a spring following a very moist summer, fall and winter.

F. brasiliensis, in Kansas, seems to be a variable species particularly as regards the mature spores. Frye and Clark (1937-1947) give the size of the mature spores as 41-48μ while we find them to range from 29-59μ. In one collection (M1358) the size range was 33-42μ with the average being 39μ or some 2μ below the minimum given for the species. Another large collection (M1269) has spores ranging from 29-40μ with the average being 35μ or some 6μ below the minimum. This is in contrast with a third collection (M5339) which has a spore size range of 46-59μ, an average size of 52μ which is 4μ above the maximum described for the species. All of our spores have some perfectly formed meshes on the convex face. These meshes are, however, very irregular even on spores from the same sporangium. The number of meshes varies from 4-14 and the size of mesh varies from 3.3-16μ. Frye and Clark (*l. c.*) state that some spores are regularly reticulate with 11-12 meshes on the convex face while usually spores have irregularly forked lamellae without distinct meshes. None of our spores, then, agree with the descriptions given for the species.

Another character of the spore which seems at variance is the height of lamellae. Frye and Clark (*l. c.*) say the lamellae are low and illustrate a spore in which lamellae are low. Our spores have prominent lamellae which are up to 4.9μ high. Sharp (1939) mentions in his key to *Fossombronia* species that the lamellae are high.

The inner faces of the spores are not mentioned in descriptions of the species. In ours the inner faces are smooth, minutely granulate or occasionally very faintly ridged.

The pseudoperianth of *F. brasiliensis* is described as turbinate, about 1.5 mm. high, deeply cleft on one side, crispate at mouth, deeply and irregularly sinuate lobed; the lobes rounded and entire. This in general matches our material except that the lobes are often more acute than rounded, have a few dentate teeth, and the sinuate lobing appears to be quite regular. Another feature of our turbinate pseudoperianths is the presence of a few lateral scales, usually reddish in color, on the sides of the structure near the base.

In many respects our *F. brasiliensis* seems very close to *Fossombronia foveolata.* Frye and Clark (1937-1947) separate *F. brasiliensis* from *F. foveolata* by the former having either no meshes on the convex surface or only 0-13 while *foveolata* has 15-20. Our material seems to be intermediate between the two in these re-

spects. Sharp (1939) separates the two by keying *F. brasiliensis* as having ridges on spores high, enclosing depressed areas 10-13μ in diameter and *F. foveolata* as having ridges on spores low, enclosing depressed areas 7-9μ in diameter. Again our material will not key out following such characters.

A comparison of our material with that from other areas reveals even more difficulties. Collections of *F. foveolata* by the writer, from Arkansas, Louisiana and Texas and by Schuster from Minnesota and Mississippi have been studied. These show the meshes of *F. foveolata* to be far less regular than described for the species. Spores range in size from 32-61μ in diameter and ridges are from 0-4.2μ high. The pseudoperianth also varies and grades into that of *F. brasiliensis*. The only constant differences now observed between the species is a tendency for the spores of *F. foveolata* to have ridges lower, and less dark in color than in *F. brasiliensis* and for meshes to be a little more regular in *F. foveolata*. Vegetative characters of the two species seem to be similar and equally variable.

From evidence at hand it would seem that *F. brasiliensis* should be treated as a variety or forma of *F. foveolata*. Until more material is available for study, however, it seems best not to change taxonomic rank of the plants involved at this time.

The study of *Fossombronia* species in Kansas is handicapped by the short fruiting period, which lasts barely two weeks in any given season. Consequently sterile plants have been found frequently which could not be identified. Most of these would probably come within the present concept of *F. brasiliensis*.

Distribution: *Chautauqua County:* 2 miles northeast of Sedan, on side of moist sandstone rock ledge, April 5, 1952, M5339. *Leavenworth County:* 4 miles northeast of Tonganoxie, sandy soil in prairie, May 15, 1948, M1438. *Montgomery County:* 3 miles southwest of Elk City, sandy path in oak woods, April 10, 1948, M1269. *Wilson County:* 1 mile northeast of Neodesha, sandy soil over surfacing sandstone, April 10, 1948, M1271. *Woodson County:* 2 miles northwest of Yates Center, sandy soil of roadside cut, May 12, 1951, M4812.

In addition to the above records sterile material of *Fossombronia* has been found in Allen, Cherokee, Douglas, Franklin, Greenwood, Jefferson, Linn and Neosho counties. As mentioned above most of these plants are probably *F. brasiliensis*.

46. *Fossombronia foveolata* Lindb. Rare. Habitat of the above species. Three collections of *Fossombronia* are referred to this con-

cept because they seem to match descriptions and specimens of the species within certain limits. For a discussion of this species see under *F. brasiliensis.*

Distribution: *Chautauqua County:* 2 miles north of Sedan, sandy soil in forest clearing, April 5, 1952, M5344. *Cherokee County:* 5 miles east of Baxter Springs, sandy-clay soil, path in oak woods, April 30, 1948, M1358. *Woodson County:* Lake Fegan, on moist sandstone ledge, April 24, 1949, M4134a.

PELLIACEAE

47. *Pellia epiphylla* (L.) Corda. Rare. This species was found once in the Ozark area of extreme southeastern Kansas where it occurred on a seepy limestone ledge in a shaded ravine. Plants were abundant on the ledge for a distance of several feet. A search of nearby similar sites failed to reveal more plants and repeated visits to the first collection point, in subsequent years, have indicated that the colony has disappeared. The site from which the collection was made regularly dries up each summer, and is covered by leaves and other debris. It was burned over in early spring following the season in which the colony was discovered. This may have been responsible for its disappearance.

Distribution: *Cherokee County:* 5 miles east of Baxter Springs, moist limestone ledge, July 31, 1948, M1933.

RICCARDIACEAE

48. *Riccardia pinguis* (L.) Gray. Rare. The known range of this species in Kansas is truly remarkable. It was found once in mouse runways in a cattail-sedge marsh in Meade County. At this site the marsh is due to artesian water and is bounded by buffalograss or short-grass prairie. The other site is in Montgomery County where the plants are found on the sides of a small, moist, sandy ditch below a spring in an oak forest. In the latter habitat the plants have been observed year after year; but a search of other similar locations in the same area and elsewhere has failed to turn up additional stations for the species.

Distribution: *Meade County:* Meade County State Park, mouse runways in cattail-sedge marsh, May 8, 1942, W. H. Horr. *Montgomery County:* 3 miles southwest of Elk City, sandy, moist ditch below a spring, July 1, 1947, M1270; September 22, 1951, M5222; October 9, 1953, M7311.

REBOULIACEAE

49. *Asterella tenella* (L.) Beauv. Scattered in the eastern half of Kansas where it seems to be limited to sandy soils and sandstone ledges. Where found it is usually very abundant though it is absent from many stations where the habitat seems suitable in every way.

Asterella tenella is often found on sandy soils on prairie hillsides dominated by *Andropogon gerardi, Bouteloua curtipendula* and in which clumps of the cactus *Opuntia humifusa* are conspicuous. In such places it is extremely xerophytic. In the same area it is found on the underside of overhanging, dripping sandstone ledges which occur along prairie ravines or creeks. The species seem to exist better in the more xeric stations and certainly fruits more abundantly on such sites.

Distribution: *Chautauqua County:* 3 miles northeast of Sedan, sandstone ledge, May 1, 1948, M1366; 3 miles north of Elgin, sandy prairie hillslope, April 5, 1952, M5347. *Cherokee County:* 5 miles east of Baxter Springs, sandy clay soil, clearing in oak woods, April 30, 1948, M1359. *Clay County:* 5 miles north of Morganville, sandy prairie hillside, August 16, 1951, M5064. *Douglas County:* 12 miles south of Lawrence, sandy bank, April 18, 1948, M1337. *Ellsworth County:* 5 miles east of Carneiro, sandy soil under sandstone ledge, April 30, 1949, M2702. *Labette County:* 8 miles northeast of Cherryvale, sandy prairie bank, June 30, 1947, M1067. *Leavenworth County:* 4 miles northeast of Tonganoxie, sandstone ledge, May 7, 1948, M1402. *Montgomery County:* 3 miles southwest of Elk City, sandstone ledge, and sandy prairie hillside, July 1, 1947, M1069. *Neosho County:* 4 miles northeast of Morehead, sandy roadside bank, June 30, 1947, M1066. *Rice County:* 1 mile east of Geneseo, sandy prairie bank, April 30, 1949, M2714. *Saline County:* 2 miles northwest of Brookville, sandy prairie ravine, April 30, 1949, M2694. *Wilson County:* 1 mile northeast of Neodesha, thin sandy soil over surfacing sandstone, May 1, 1948, M1381. *Woodson County:* Lake Fegan, under overhanging sandstone ledge, September 24, 1949, M4130. *Wyandotte County:* 1 mile northeast of Bonner Springs, sandy bank in road cut, May 15, 1948, M1439.

50. *Mannia fragrans* (Balb.) Frye and Clark. Abundant on a number of sites in the eastern half of Kansas where it is found on dry exposed sandy prairie hillsides and on moist sandstone ledges which are moist only in the spring. The species is very xerophytic and occurs only on sandy soil or sandstone.

A characteristic habitat for *M. fragrans* consists of prairie hill-

sides characterized by a mixture of *Andropogon gerardi, Andropogon scoparius, Bouteloua curtipendula, Anemone caroliniana, Opuntia humifusa* and thickets of *Rhus glabra.* It is also commonly found in mixed prairie of the above plants with *Quercus stellata, Q. marilandica* and *Q. velutina.*

The plants fruit abundantly from April to June after which they become inconspicuous, since the drying, shriveling, thallus margins roll up and overlap or become strongly incurved exposing the very black-purplish underside. At such times the plants are easily overlooked as they are covered by grass, dust, or otherwise partially hidden. The application of a bucket of water causes them to unroll quickly and after early fall rains they unroll and continue growth.

Kansas material of this species varies considerably in the position and arrangement of antheridia. The description of the antheridia as given by Frye and Clark (1937-1947) states that the antheridial receptacle is sessile, distinct, oval to broadly lunate, limiting the growth of the somewhat elongate male branch. This is true of some of our plants in that they have an antheridial disk at the tip of the thallus which does prohibit further growth of the thallus segment. However, many of the male thallus branches have antheridia in a scattered group near the tip but they also extend back from this in the dorsal groove for ½-¾ of the length of the thallus branch. Such an arrangement does not prohibit increase in length of that segment and it does continue to grow. This disagrees with the European and American descriptions given for the species but agrees with the findings of Schuster (1952) on material of the species from Minnesota.

In addition our specimens show that the carpocephala are nearly always developed at the tip of a thallus branch and on the dorsal surface. Occasionally they develop on short, lateral ventral branches. The former condition is characteristic of the species as previously conceived while the latter is not. Schuster (1953) found in Minnesota that a well-developed tendency for development of carpocephala on ventral branches occurred. This tendency is weakly expressed in Kansas material.

The above variations do not seem constant enough to call for taxonomic segregation of subspecies. Much more work over the range of the species will have to be done. It is felt that we are dealing with a fairly common hepatic which has not received critical attention and thus the variable characters perhaps escaped notice.

Distribution: *Anderson County:* 2 miles south of Garnett, sandy-

clay soil, June 4, 1951, M4874. *Chautauqua County:* 3 miles northeast of Sedan, sandy bank in oak woods, March 26, 1948, M1216; sandy soil, prairie hillside, April 5, 1952, M5340. *Coffey County:* 2 miles southwest of LeRoy, sandy cliff, April 9, 1948, M1239. *Crawford County:* Farlington Tree Farm, September 17, 1949, L. J. Gier 2365. *Douglas County:* 3 miles southeast of Baldwin City, sandy prairie ridge, April 2, 1948, M1225; 12 miles south of Lawrence, sandstone ledge, October 13, 1951, M5246. *Elk County:* 10 miles north of Busby, sandy trail in oak woods, April 10, 1948, M1283. *Ellsworth County:* 3 miles northeast of Geneseo, moist sandstone ledge, April 13, 1948, M1309; 5 miles northwest of Langley, shaded sandy bank in prairie ravine, May 3, 1952, M5447; 6 miles southeast of Kanopolis, sandstone cliff, May 3, 1952, M5454. *Jefferson County:* 1 mile west of Medina, sandy prairie slope, April 2, 1948, M1235. *Greenwood County:* 1 mile northeast of Fall River, sandstone ledge in prairie ravine, April 10, 1948, M1293. *Labette County:* 5 miles southwest of Dennis, sandy roadside bank, April 10, 1948, M1265. *McPherson County:* 2 miles northwest of Lindsborg, sandstone ledge, May 3, 1952, M5457. *Montgomery County:* 3 miles southwest of Elk City, April 4, 1942, R. H. Thompson; 6 miles south of Elk City, sandy soil, March 26, 1948, M1181. *Neosho County:* 2 miles northeast of Chanute, sandy slope in oak forest, April 9, 1948, M1257. *Washington County:* 2 miles west of Linn, sandstone ledge, August 22, 1952, M5713. *Wilson County:* 1 mile northeast of Neodesha, sandy soil over surfacing sandstone, April 10, 1948, M1271; April 5, 1952, M5331. *Woodson County:* 2 miles northwest of Yates Center, sandy prairie, April 9, 1948, M1242.

51. *Plagiochasma rupestre* (Forst.) Steph. Rare. This southwestern species has been found once in Kansas extending its range considerably north of previous records from Oklahoma. However, a collection is in the herbarium of the University of Kansas from Clay County, Missouri, collected by L. J. Gier 1179 on July 26, 1948, which extends the known range to west-central Missouri. The plants were growing on the side of a sandstone outcrop in a wooded ravine.

Distribution: *Woodson County:* 8 miles south and 4 miles west of Yates Center, sandstone outcrop, September 27, 1952, M6084.

52. *Reboulia hemisphaerica* (L.) G. L. and N. Common in the eastern half of the State. It tolerates a wide range of habitat variations and is met with frequently in our area. It seems to exhibit a preference for sandstone or sandy situations and is rather uncommon

on limestone and calcereous soils. This may be due to the shortage of moisture so usual on limestone sites in Kansas.

R. hemisphaerica is usually to be found on the sides of sandstone outcrops, in crevices and sometimes on moist sandy soil below outcrops. It seldom grows upon soil unless in moist shaded conditions. Even though the plant requires a moist habitat it can survive severe drying and is therefore one of our more xeric hepatics. During hot dry summers the thallus will curl up exposing the black-purple ventral surface. Normally most of the thallus will winter kill leaving only the tips alive. These may continue growth or if they contain antheridia and archegonia they will result in the formation of fruiting bodies.

This species is found characteristically to form rosette patterns on rock faces and becomes gregarious only during unusually moist seasons or when on moist soil.

Distribution: *Anderson County:* 5 miles south of Garnett, on moist limestone rock ledge, October 8, 1948, M2484. *Chautauqua County:* 3 miles northeast of Sedan, on side of sandstone ledge, May 1, 1948, M1365; April 12, 1950, M4193; April 5, 1952, M5336. *Cherokee County:* 5 miles east of Baxter Springs, moist limestone ledge, April 30, 1948, M1360. *Clay County:* 1 mile southwest of Longford, sandstone ledge, May 23, 1948, M1513. *Cloud County:* September 13, 1948, S. V. Fraser. *Cowley County:* 2 miles southeast of Arkansas City, sandy bank, September 2, 1950, M4643. *Crawford County:* 1 mile east of Pittsburg, sandy bank, April 11, 1952, M5354. *Dickinson County:* 8 miles northeast of Solomon, sandstone ledge, May 23, 1948, M1512. *Douglas County:* 12 miles south of Lawrence, sandstone ledge, April 18, 1948, M1336; 5 miles west of Baldwin City, sandstone ledge, October 15, 1949, M4146; April 22, 1950, M4232; April 26, 1952, M5440. *Elk County:* 10 miles north of Busby, sandstone ledge, April 10, 1948, M1284. *Ellsworth County:* 3 miles northeast of Geneseo, April 13, 1948, M1308; 6 miles south of Kanopolis, sandstone ledge, May 3, 1952, M5455. *Franklin County:* 4 miles southwest of Ottawa, sandstone ledge, June 18, 1949, M3094; August 2, 1949, M3611; May 12, 1950, M4248. *Geary County:* 2 miles southeast of Junction City, moist limestone ledge, April 30, 1949, M2716. *Greenwood County:* 1 mile northeast of Fall River, margin of sandstone outcrop, April 10, 1948, M1294. *Harper County:* 1 mile west of Danville, sandy moist roadside bank, August 18, 1948, M2233. *Jefferson County:* 1 mile west of Medina, sandy bank, Nov. 16, 1947, M1136. *Labette County:* 5 miles southwest of Dennis, sandstone ledge, April 10, 1948, M1266.

Lincoln County: 10 miles southeast of Lincoln, sandstone ledge, September 4, 1950, M4650. *Leavenworth County:* 4 miles northeast of Tonganoxie, side of sandstone outcrop, May 7, 1948, M1401. *McPherson County:* 2 miles northwest of Lindsborg, on sandstone outcrop, July 24, 1948, M1822; May 3, 1952, M5458. *Miami County:* Miami County State Park, on limestone rocks, October 19, 1947, M1112. *Mitchell County:* 1 mile northwest of Simpson, sandstone outcrop, September 4, 1950, M4652. *Montgomery County:* 3 miles southwest of Elk City, on sandstone rocks, April 4, 1942, R. H. Thompson. *Nemaha County:* Nemaha County State Park, on sandy bank, August 9, 1948, M2019. *Neosho County:* 2 miles northeast of Chanute, on sandstone ledge, April 9, 1948, M1258. *Osage County:* 6 miles south of Quenemo, on sandstone cliff, July 1, 1949, M3323. *Ottawa County:* 2 miles southwest of Minneapolis, sandy soil below ledge, April 14, 1948, M1316. *Rice County:* 2 miles southwest of Crawford, sandy roadside bank, July 24, 1948, M1828. *Riley County:* 3 miles southwest of Manhattan, limestone ledge, April 30, 1949, M2720. *Russell County:* 7 miles north of Dorrance, base of sandstone ledge, June 25, 1949, M3292. *Saline County:* 2 miles northwest of Brookville, on sandstone outcrop, May 22, 1948, M1480. *Shawnee County:* 3 miles northeast of Topeka, sandstone ledge, April 2, 1948, M1231. *Washington County:* 1 mile west of Linn, sandstone outcrop, April 15, 1948, M1328; August 10, 1948, M2056; August 22, 1952, M5722. *Wilson County:* 3 miles west of Neodesha, limestone ledge, June 30, 1947, M1064; 1 mile northeast of Neodesha, sandstone ledge, May 1, 1948, M1382. *Woodson County:* 2 miles northwest of Yates Center, sandstone ledge, April 9, 1948, M1243; September 27, 1952, M6083.

CONOCEPHALACEAE

53. *Conocephalum conicum* (L.) Dumort. Found in the eastern fourth of Kansas where it is largely confined to the vertical sides of sandstone ledges along creeks or moist hillsides. It regularly forms large, extensive mats over the surface of the rocks and will extend on soil at the base of the rocks if the soil is moist. Less frequently it occurs on boulders on the stream margins and hard packed sandy alluvium. Occasionally, small patches of this species have been found at the base of seepy limestone outcrops but such colonies never persist for more than a season.

In Kansas *Conocephalum conicum* fruits very rarely. In fact it seldom seems to produce reproductive structures and when produced they are usually winter killed. This liverwort does not

tolerate xeric conditions and is limited in Kansas to sites which are moist even during the driest of seasons. Drought seasons invaribly reduce the size of colonies and completely eliminates them in limestone stations. The lack of spore production and inability to tolerate drouth, in Kansas, restricts the occurrence of this species in the State. This explains the fact that in normal moisture seasons many apparently favorable sites do not have *Conocephalum conicum* as part of their hepatic flora.

Distribution: *Chautauqua County:* 3 miles northeast of Sedan, side of sandstone ledge, July 1, 1947, M1072; July 8, 1949, 3380; April 12, 1950, M4192. *Cowley County:* 4 miles southeast of Arkansas City, seepy limestone ledge, July 23, 1947, M1076. *Douglas County:* 5 miles west of Baldwin City, side of sandstone outcrop, June 24, 1947, M1057; April 2, 1948, M1221; April 18, 1948, M1338; April 22, 1950, M4230. *Franklin County:* 5 miles northeast of Ottawa, side of sandstone ledge, October 15, 1949, M4151. *Greenwood County:* 1 mile east of Fall River, on sandstone ledge, July 9, 1949, M3411. *Leavenworth County:* on side of sandstone outcrop, July 27, 1947, M1077. *Montgomery County:* 5 miles southeast of Elk City, sandstone boulders, July 17, 1947, M1074. *Wilson County:* 3 miles west of Neodesha, on side of seepy limestone ledge, June 30, 1947, M1063. *Woodson County:* 3 miles northwest of Yates Center, sandstone cliff, June 29, 1947, M1061; June 19, 1949, M3198. *Wyandotte County:* 5 miles northwest of Bonner Springs, sandstone cliff, July 27, 1947, M1079; May 21, 1949, M2744.

MARCHANTIACEAE

54. *Marchantia polymorpha* L. Widely dispersed over the eastern half of the State. It occurs on both sandstone and limestone ledges, showing no preference for either. In our area this species may be expected on any rocky ledge or outcrop which is moist or from which a spring flows. The distribution, however, is localized and the species is seldom found. The absence of the species from most of the favorable sites is unexplainable.

Throughout late summer one can find *M. polymorpha* on alluvial deposits of our creeks and rivers. It occurs rather evenly distributed in all such places in the eastern two thirds of the State. Yet "mother colonies" are rarely found and are never in abundance.

At one hill-top site, plants were found in a woods which had been thinned, and the debris raked into small piles and burned.

Each such burned area contained an abundance of both male and female fruiting thalli. These occurred only on the circular burned areas.

Our collections of this species show all the usual variations met with in this polymorphic taxon. In a few springs at the base of sandstone cliffs one finds the forma *aquatica* Nees, but it intergrades completely with strand plants. Other plants have been found on the sides of sandstone cliffs which could be called forma *alpestris* Nees, but again intergradation seems complete and subspecific names are apparently useless in our area.

In the list which follows showing distribution all stations, regardless of habitat or abundance, are noted. In some of these only a few gemma-cup-bearing dichotomies were found along alluvial deposits of streams. The plants are not anywhere nearly as common or abundant as the distributional data would seem to indicate. A bryologist, unfamiliar with Kansas, might search for days in the State and never see a single specimen of *M. polymorpha.*

Distribution: *Anderson County:* 2 miles south of Garnett, alluvial deposit, June 19, 1949, M3207. *Brown County:* 5 miles northeast of Hiawatha, alluvial deposit, September 7, 1948, M2434. *Chase County:* 1 mile south of Strong City, bank of river, November 27, 1948, M2604. *Coffey County:* 2 miles north of Burlington, river bank, November 26, 1948, M2594. *Douglas County:* 5 miles northwest of Lawrence, bank of Kansas River, May 14, 1948, M1444; University of Kansas Campus, under library steps, June 13, 1949, M3063; 3 miles north of Baldwin City, side of sandstone rock, October 14, 1951, M5253; May 10, 1952, M5467. *Ellsworth County:* 3 miles northeast of Geneseo, side of sandstone cliff, April 13, 1948, M1313; May 22, 1948, M1501. *Franklin County:* 3 miles east of Pomona, river bank, June 8, 1948, M1576; 1 mile southeast of Ottawa, on alluvial deposit, June 28, 1949, M3307. *Geary County:* 2 miles southeast of Junction City, river bank, April 30, 1949, M2715. *Leavenworth County:* 2 miles northwest of Leavenworth, moist limestone ledge, September 7, 1948, M2430; 2 miles west of Linwood, sandy creek bank, June 16, 1949, M3083, M3085. *Lyon County:* 1 mile north of Emporia, on alluvial deposit, November 26, 1948, M2597. *Marion County:* 1 mile south of Florence, river bank, November 27, 1948, M2608. *Marshall County:* ½ mile east of Blue Rapids, river bank, August 9, 1948, M2037. *McPherson County:* 2 miles northwest of Lindsborg, on sandstone ledge, July 24, 1948, M1823. *Miami County:* Miami County State Park, alluvial deposit

along river, October 3, 1948, M2469; October 17, 1949, M4157. *Osage County:* 2 miles north of Vassar, river bank, June 8, 1948, M1572. *Ottawa County:* 2 miles south of Wells, on moist sandstone outcrop, April 14, 1948, M1320; May 21, 1948, M1468. *Rice County:* 2 miles southwest of Crawford, on sandstone ledge, July 24, 1948, M1830. *Riley County:* bank of Kansas River, October 22, 1948, T. E. Brooks. *Saline County:* 2 miles northwest of Brookville, on sandstone outcrop, May 22, 1948, M1477. *Washington County:* 1 mile west of Linn, moist sandstone outcrop, April 15, 1948, M1328; August 10, 1948, M2057; August 22, 1952, M5718. *Wilson County:* 1 mile northeast of Neodesha, on burned over brush pile site, May 1, 1948, M1380. *Woodson County:* 2 miles northwest of Yates Center, alluvial soil, June 19, 1949, M3199. *Wyandotte County:* 2 miles southeast of Wolcott, below a spring on limestone outcrop, September 6, 1948, M2420.

OXYMITRACEAE

55. *Oxymitra paleacea* Bischoff. Found in six counties in the southeastern quarter of Kansas where it grows only on sandy soil over surfacing sandstone or on sandy soil in rocky bluestem prairie. It may be found on dry sandy ledges, open places in oak woods and along trails.

This species is an extreme xerophyte and regularly has its sides roll up and recurve onto the dorsal surface. In such a position the large ventral scales overlap and cover the thallus. In such a condition the plants are capable of passing through long severe dry periods.

O. paleacea fruits in September-November during normal seasons. A dry summer, however, delays early fall growth resulting in the maturation of spores the following spring. Plants are always found in gregarious colonies which may cover an area of several square yards.

In North America *Oxymitra paleacea* is known from Mexico, central Texas, through Oklahoma and into Kansas. The Texas plants were discovered first and named as *Oxymitra androgyna* by Howe (1914). Previous to that time only one species, *Oxymitra paleacea* Bischoff, was known and it had been found in Europe, Africa and South America. Howe (*l. c.*) described the Texas material as a new species and separated the North American material on the basis of spore size (which he gave as 125-175μ) while the European, African and South American material was believed to have spores 100-120μ in diameter. The European plants were uni-

sexual and the North American were bisexual with an occasional tendency toward the unisexual condition. In addition the walls radiating from the pores were thought to be thicker in North American material than in the other known species.

Recently Müller (1952) reduced *Oxymitra androgyna* Howe to a synonym of *Oxymitra paleacea* Bischoff. In this we concur. The writer has collected or studied specimens of *Oxymitra* from localities throughout its known range in North America. We find that the use of spore size completely fails as a specific criterion. Wittlake (1953) has shown that spore size of Kansas *Oxymitra* ranges from 90 to 180μ thus in its lower range going below that given for the European material, and much surpassing the maximum size of the European spores. The writer finds North American spores to have the range as given by Wittlake (1953) but most consistently to fall into a range of 118-140. Spores of material which we have studied from France and Italy range from 82-142μ with most of them being in a range between 115-132μ. Thus spore size in plants of the two continents are very similar and show only that those from North America tend to be a little larger.

The walls radiating from the pores in North American and European plants vary over the same range, and therefore are of no taxonomic importance.

In North American material we have found that thalli are bisexual and unisexual with most of it being of the former type. However, unisexual plants are not uncommon and are found in all collections made. The only European material we have been able to study (France and Italy) revealed that both conditions existed, but material was too scarce to gain any idea of the relative frequency of each type. In American material 9 bisexual thalli were found for every 2 that were unisexual. In some one segment was bisexual while the sister segment was unisexual.

Wittlake (1953) describes the spore of *Oxymitra paleacea* (= *O. androgyna*) as having areolae too variable to consider. This we do not find to be the case, since the spore, illustrated by Wittlake, is characteristic and shows areolae to be quite regular in size or at least as regular as one would expect areolae to be on spores in the Oxymitraceae and related Ricciaceae. We find the largest areolae to be 42μ in greatest diameter and the smallest to be 24. However, out of a great number measured we find them to fall consistently in the range of 30-40μ. Wittlake (1953) also gives the length of the projections of the spore (verrucae) as .5-2μ while we find them to be rather consistently 3.3μ long and range from .2-6.7μ.

Oxymitra paleacea, as now understood, exhibits a striking geographic distribution. It is found in Europe, North Africa, Brazil, Argentina, Paraguay, Mexico, and in Texas, Oklahoma and Kansas in the United States. The Mexico record is not reported in the literature but collections in the herbarium at the University of Kansas by E. B. Wittlake 50241 taken on July 2, 1953, 2 miles southeast of Tecamachalco, Puebla and McGregor 8029 from Tamuzunchale, San Luis Potosí, constitute valid records for Mexico.

Distribution: *Chautauqua County:* 3 miles east of Sedan, sandy prairie, edge of oak woods, March 26, 1948, M1209; May 8, 1949, W. H. Horr; 4 miles south of Sedan, sandy soil, July 8, 1949, M3370; 1½ miles northeast of Sedan, sandy open wooded prairie, April 5, 1952, M5346. *Elk County:* 10 miles north of Busby, sandy soil over surfacing sandstone, April 10, 1948, M1287. *Greenwood County:* 1 mile northeast of Fall River, edge of surfacing sandstone, April 10, 1948, M1291; 1 mile east of Fall River, sandy soil, April 13, 1949, M2670; July 9, 1949, M3409; August 21, 1949, R. H. Thompson. *Montgomery County:* 3 miles southeast of Elk City, sandy soil, April 4, 1942, R. H. Thompson; 3 miles southwest of Elk City, sandy open wooded hillside, October 25, 1947, M1119; 6 miles south of Elk City, sandy soil, March 26, 1948, M1185; 3 miles southwest of Elk City, sandy soil, September 22, 1951, M5230. *Wilson County:* 1 mile northeast of Neodesha, sandy soil, October 25, 1947, M1115; April 10, 1948, M1272. *Woodson County:* 2 miles northwest of Yates Center, sandy soil, October 26, 1947, M1124; April 9, 1948, M1244; Lake Fegan, sandy soil, March 26, 1949, M2648; 2 miles northwest of Yates Center, sandy soil, June 19, 1949, M3200; Lake Fegan, sandy soil, edge of sandstone outcrop, September 24, 1949, M4129; 2 miles northwest of Yates Center, shallow sandy soil over surfacing sandstone, October 28, 1941, M5274.

RICCIACEAE

56. *Ricciocarpus natans* (L) Corda. Rare. Found in a few swamps, lakes and ponds in eastern Kansas where it floats on the surface of the water. Land forms also occur at the above habitats in late summer and fall as the water level recedes. These land forms are also to be found occasionally on alluvial deposits along streams in the eastern part of the State.

In Kansas *R. natans* (water form) fruits abundantly in early spring and then passes into a vegetative phase during which it reproduces actively by division and fragmentation of thalli. These water forms persist into winter and eventually are frozen in ice.

One station was observed through several seasons. At this site the floating forms regularly are frozen in ice in early winter. This results in death of the posterior portion of the plants. This early freeze invariably is followed by complete thawing during which plants undergo some growth. Through the rest of the winter season successive freezing and thawing takes place. Never is *R. natans* killed by being frozen in ice even when frozen for a period of several weeks. The result is that by spring many small thalli tips are present on the body of water. These grow rapidly and produce typical fruiting plants.

In the summer and early fall many of the floating plants are left stranded on muddy banks by receding water. These plants develop into rosettes or irregularly gregarious colonies of the land form and become submerged with the advent of fall rains. Such submerged colonies exist through the winter and in the spring the tips of the apices produce small plantlets which become detached, float to the surface, and develop into fruiting individuals.

The finding of some strand plants along creek and river banks indicates that the distribution of this species, at least in northeast Kansas, is greater than the distribution listed below would seem to indicate. However, we have found some strand plants on creek banks whose drainage area is completely known and in which no floating plants have been found. The occurrence of such plants is not explainable unless they developed from spores carried in or blown into the watershed area.

Distribution: *Atchison County:* ½ mile south of Muscotah, mud bank of Little Grasshopper Creek, October 18, 1947, M1105. *Douglas County:* 1 mile north of Lawrence, alluvial deposit of Kansas River, November 13, 1948, M2593; 3 miles northeast of Lawrence, floating in cattail-sedge marsh, November 6, 1948, R. H. Thompson; 1 mile northeast of Lawrence, floating in old ox-bow marsh, August 27, 1949, M3893; November 13, 1949, M4163; September 23, 1950, M4676; 2 miles northeast of Lawrence, alluvial deposit on bank of Kansas River, August 9, 1952, M5686. *Jefferson County:* 3 miles west of Williamstown, floating in cattail marsh, November 13, 1949, M4165. *Johnson County:* ½ mile north of De Soto, alluvial deposit on bank of Kansas River, July 27, 1952, M5668. *Leavenworth County:* 2 miles north of Leavenworth, alluvial deposit bank of Missouri River, October 29, 1948, M2582. *Linn County:* 2 miles west of La Cygne, floating in cattail marsh, June 4, 1949, M2855. *Miami County:* Murray Lake, Miami County

State Park, alluvial deposit, October 19, 1947, M1114; Pigeon Lake on Hugh Whitford Ranch, on alluvial deposit, April 24, 1948, M1348; 3 miles east of Fontana, bank of Marais des Cygnes River, October 3, 1948, M2470; Pigeon Lake, mud bank, November 12, 1949, M2579; Pigeon Lake, floating, May 29, 1949, M2772; October 17, 1949, M4158; October 8, 1950, M4681.

57. *Riccia beyrichiana* Hampe. Found over most of Kansas except the northwest quarter and rare in the southwest quarter. This species ranks with *Frullania inflata* and *Riccia frostii* as the mostly widely distributed species of hepatic in the State. It tolerates a wide range of habitats but is most common on sandy soils associated with surfacing sandstone in prairie and oak forest. In moist seasons it is scattered in limestone areas, particularly in mixed forest and prairie sites. It is also to be found on alluvial deposits along river banks, flood plains, roadside ditches, and deposits from eroded fields.

R. beyrichiana is one of the most easily recognized species in the genus; nevertheless it is quite variable in many respects. In our specimens we find the margin characteristically has one or two rows of stout, usually curved cilia from 30 to 300μ long. These are always prominent at the apex but become less frequent posteriorly. Never are they absent. Macvicar (1926) says that specimens from England most frequently have naked margins and Müller (1952) concurs in this for European material. Frye and Clark (1937-1947) report that cilia are rarely wanting, usually few in number, in 1 or 2 series, stout and often curved. Kansas specimens are more as described by Frye and Clark in this character but seem to show even a more pronounced tendency for frequent, stout, curved cilia. Occasionally specimens found in the shade or on very moist soil show a tendency for cilia suppression; but never is the margin without them.

The coloration of the thallus sides is usually greenish in Kansas specimens except for those on drier or exposed sites where the color may range from reddish to black-purple. Ventral scales likewise are usually hyaline to whitish but may become purplish on dry exposed habitats.

Thallus size varies also with the habitat. On exceptionally dry areas, the length may be from 7-12 mm. and the width from 1-2 mm. On more favorable sites the length is usually 5-10 mm. and the width 2-4 mm. The thickness of the thallus, width of the dorsal groove, and the angle of margin also vary with respect to moisture and light conditions.

The spore differs in some characters given by certain different workers. Frye and Clark (1937-1947) and Howe (1923) give the size range of greatest spore diameter as 65-140μ for American material. Macvicar (1926) gives the range as 95-120μ for English specimens; while Müller (1952) gives the spore size as 100-120μ, and Schuster (1953) 90-130μ. Kansas material shows, on the basis of an examination of spores from all the collections listed below, that the range in size of mature spores is 74-138μ. However, the overall average of spore size is 106μ. The spore size, as a taxonomic character, must be used with caution, as a given colony often has a range different from that of another. My collections M4143 and M5446, for example, show that the range of spore size in M5446 is 75-112μ, and the average size is 90μ; while M4143 has a range of 115-138μ, and an average spore size of 124μ. Thus the spores of M4143 average larger than the maximum limit of spore size known for the species by Macvicar (1926) and Müller (1952). At the other extreme the spores of M5446 average 90μ or the exact size of the minimum size considered for the species by Schuster (1953). As a further comparison my collection M1353 shows a range of spore size of 99-122μ and an average size of 113μ, thus the collection falls in line with sizes as given by all the above cited workers.

Another spore character which seems to vary is the size of areoles on the outer spore face. Macvicar (1926) reports the size of areoles as reaching up to 15μ, Frye and Clark (1937-1947) give a range of 10-18μ, and Müller (1952) gives a range of 10-15μ. Müller (1952) also gives the number of areolae across the face of the spore as 6-8, and Macvicar (1926) as 7-9. We find, in our Kansas plants, that the size of areolae varies from 7.2-18.8μ in diameter and have 5-7 across the face of the spore. The average of areolae diameters is 15-17μ and the average number across spore face is 5-6. Thus Kansas material shows a tendency to fewer but larger areolae as compared to European plants.

Another spore character, that of papillae revealed when the spore is viewed in profile, seems also to vary. Macvicar (1926) states that spores are highly papillose in profile while Frye and Clark (1937-1947) refer to the papillae as being absent or obscurely present. Most of our Kansas collections show only faint signs of papillae, though occasionally, they are evident and up to 2.4μ in length. When such are observed they are found to be truncate to obtuse.

Occasionally collections of *R. beyrichiana* are obtained in Kansas

(such as M1059), which are extremely atypical as far as spore characters are concerned. The collection mentioned has spores in which no complete areolae are to be found on the outer face. Instead, rather heavy irregular ridges occur and these rarely anastomose. The area in which this collection was made has been studied extensively through several seasons and only one gregarious colony was found with such spore characters. A tendency toward this condition has been noticed in other stations. At all such places *R. campbelliana* is common and intermingled with *R. beyrichiana.* It thus seems possible that hybridization between the two might have occurred.

It seems possible that a critical study of *R. beyrichiana* in North America and Europe might show, that a part of the material (European) should be split off as a subspecies, if some of the differences noted above prove to be constant.

Distribution: *Allen County:* 5 miles north of Moran, creek bank, October 8, 1948, M2499. *Anderson County:* 1½ miles northeast of Welda, bluestem prairie, October 31, 1948, R. H. Thompson; 5 miles south of Garnett, moist bank in woods, October 8, 1948, M2482; 2 miles south of Garnett, sandy-clay soil, June 4, 1951, M4876. *Atchison County:* ½ mile south of Muscotah, creek bank, October 18, 1947, M1106. *Barton County:* ¼ mile north of Pawnee Rock, sandy prairie, August 30, 1950, M4629. *Bourbon County:* 2 miles south of Uniontown, creek bank, October 8, 1948, M2511; 6 miles south of Fort Scott, sandy-clay prairie bank, May 9, 1953, M7201. *Brown County:* 5 miles northeast of Hiawatha, sandy-clay prairie bank, September 7, 1948, M2432. *Chase County:* 1 mile south of Strong City, river bank, November 27, 1948, M2605. *Chautauqua County:* 3 miles northeast of Sedan, sandy soil, March 26, 1948, M1214; 1½ miles northeast of Sedan, sandy prairie, April 12, 1950, M4188; April 5, 1952, M5342. *Cherokee County:* 5 miles east of Baxter Springs, rocky-clay soil, open places in oak woods, April 30, 1948, M1353, M1362; 3 miles southeast of Baxter Springs, sandy bluestem prairie, October 22, 1951, M5263, M5265; 3 miles northeast of Riverton, sandy abandoned field, May 9, 1953, M7199. *Coffey County:* 2 miles southwest of LeRoy, sandy prairie, April 9, 1948, M1236; 2 miles north of Burlington, river bank, November 26, 1948, M2596. *Cowley County:* 2 miles southeast of Arkansas City, sandy prairie bank, September 2, 1950, M4642. *Crawford County:* Crawford County State Park, moist clay bank, October 9, 1948, M2528. *Douglas County:* 1 mile southeast of Lawrence, sandy soil, April 24,

1942, R. H. Thompson; 5 miles west of Baldwin City, very moist sandy soil, June 24, 1947, M1059; 2 miles southeast of Baldwin City, moist sandy soil, October 11, 1947, M1100; 5 miles west of Baldwin City, sandy bluestem prairie, June 18, 1948, M3104; October 15, 1949, M4143; September 16, 1950, M4675; October 13, 1951, M5249; April 26, 1952, M5434; 2 miles northeast of Lawrence, alluvial deposit, bank of Kansas River, June 12, 1952, M5604. *Edwards County:* 2 miles east of Kinsley, sandy prairie, August 28, 1950, M4508. *Elk County:* 10 miles north of Busby, sandy open oak woods, April 10, 1948, M1286. *Ellsworth County:* 3 miles northeast of Carneiro, sandy prairie, May 22, 1948, M1500; 4 miles northwest of Langley, sandy prairie, May 3, 1952, M5446. *Ford County:* 4 miles southwest of Dodge City, sandy soil, August 28, 1950, M4509. *Franklin County:* 1 mile northeast of Norwood, sandy soil, March 25, 1948, M1169. *Geary County:* 2 miles southeast of Junction City, river bank, April 30, 1949, M2716. *Greenwood County:* 1 mile northeast of Fall River, sandy soil, April 10, 1948, M1295. *Hamilton County:* 2 miles south of Syracuse, sandy soil, August 29, 1950, M4581. *Harvey County:* 3 miles north of Burrton, sandy soil, July 24, 1949, M3505; August 28, 1950, M4505; June 11, 1951, M4911; August 25, 1951, M5083. *Jefferson County:* 1 mile west of Medina, sandy soil, November 16, 1947, M1135. *Johnson County:* 5 miles west of Olathe, sandy prairie, November 2, 1947, M1130. *Kearny County:* Lake McKinney, edge of lake, August 29, 1950, M4590. *Labette County:* 5 miles southwest of Dennis, sandy soil edge of oak woods, April 10, 1948, M1264. *Leavenworth County:* 1 mile west of Turkey Creek Station, sandy soil, December 2, 1947, M1142; 4 miles northeast of Tonganoxie, sandy prairie, May 7, 1948, M1405; 2 miles west of Linwood, sandy soil, June 16, 1949, M3090. *Lyon County:* 1 mile north of Emporia, river bank, November 26, 1948, M2599. *Miami County:* 3 miles east of Fontana, river bank, October 19, 1947, M1107. *Montgomery County:* 3 miles north of Independence, sandy soil, April 24, 1942, R. H. Thompson; 3 miles southwest of Elk City, sandy soil, July 1, 1947, M1070; March 26, 1948, M1182. *Marion County:* 1 mile south of Florence, river bank, November 27, 1948, M2610. *Morris County:* 2 miles north of Council Grove, river bank, November 27, 1948, M2615. *Nemaha County:* Nemaha County State Park, sandy-clay soil, August 9, 1948, M1261. *Ottawa County:* Ottawa County State Park, sandy soil, May 21, 1948, M1467. *Reno County:* 6 miles northeast of Hutchinson, sandy soil, June 11, 1951, M4956; August 28, 1950, M4506; August 25,

1951, M5084. *Rice County:* 1 mile east of Geneseo, sandy prairie, April 30, 1949, M2708. *Riley County:* 3 miles southwest of Manhattan, moist wooded hillside, April 30, 1949, M2721. *Saline County:* 2 miles northwest of Brookville, sandy prairie, May 22, 1948, M1479. *Sedgwick County:* 2 miles northwest of Wichita, sandy pasture, September 2, 1950, M4649. *Shawnee County:* 5 miles east of Topeka, rocky clay bank, April 23, 1949, M2679. *Stafford County:* 1 mile west of Stafford, sandy roadside ditch, August 28, 1950, M4507. *Stanton County:* 1 mile north of Saunders, sandy soil, August 28, 1950, M4547. *Washington County:* 2 miles southwest of Palmer, sandy prairie, May 27, 1951, M4830. *Wilson County:* 1 mile northeast of Neodesha, sandy soil, June 11, 1952, M5602. *Woodson County:* 2 miles northwest of Yates Center, sandy prairie, June 29, 1947, M1062; May 12, 1951, M4807; 14 miles southwest of Yates Center, sandy oak woods, September 1, 1951, R. H. Thompson. *Wyandotte County:* 1 mile northeast of Bonner Springs, sandy soil, May 15, 1948, M1440.

58. *Riccia bifurca* Hoffm. Rare. Found but three times in Kansas and known only from alluvial deposits along streams. It therefore is not a characteristic species in our hepatic flora. In each of the three stations where the species was taken we have since failed to locate more specimens. The occurrence of the species on alluvial deposits indicates that plants must occur elsewhere in our area but as yet they have not been found.

Our plants agree in all respects with descriptions of the species and with specimens seen from other areas. Two rosettes of number M2521, however, would be referred to *R. bifurca* var. *subinermis* Heeg on the basis of the presence of a few acutely pointed cilia on the margin of terminal segments. This character does not seem worthy of taxonomic recognition in this instance, and the specimens are therefore not segregated.

Some difference of opinion is apparent in the literature as to the correct name for this species. Frye and Clark (1937-1947) recognize *Riccia bifurca* Hoffm. and reduce *R. arvensis* Aust. to a synonym of it. Müller (1952) also considered *R. arvensis* as a synonym; but Schuster (1949, 1953) recognizes *R. bifurca* as a synonym of *R. arvensis.* A study of North American specimens named *R. arvensis* by Austin (1870) shows that they are identical with the plants in Europe known as *R. bifurca.* It thus is necessary to recognize *R. bifurca* as the valid name.

Distribution: *Cherokee County:* 5 miles east of Baxter Springs,

bank of Shoal Creek, October 9, 1948, M2521. *Douglas County:* north edge of Lawrence, bank of Kansas River, May 1, 1951, R. H. Thompson. *Riley County:* bank of Kansas River, October 22, 1948, Travis Brooks.

59. *Riccia campbelliana* Howe. Common on sandy soil in prairie and open oak wooded areas. It is most frequent on shallow soil over surfacing sandstone and in bluestem prairies near such environments. Occasional plants are found on alluvial soil along stream banks. As yet this species has not been found on calcareous sites.

The distribution of *Riccia campbelliana* in the United States, based on the literature, is somewhat confusing. The species was described by Howe (1899) based on material from California. Later Howe (1923) gave the range of the species as California and Texas. Frye and Clark (1937-1947) list the species as definitely known only from California. Jacobs (1951) reported the species from Arkansas and Georgia, and refers to California records. This distribution, to Jacobs, seemed to provide a remarkable parallel to the disjunct ranges of several vascular plants. However, both Jacobs, and Frye and Clark overlooked a paper by McAllister, Hoglund, and Whitehouse (1932) in which *R. campbelliana* was listed from four stations in Texas. The distribution of the species, based on specimens seen by the author or collected by him, is now known to be California, central Texas north through Oklahoma to northeastern Kansas; then southeastward to central Arkansas, to northwestern Louisiana and southwest to central Texas. In addition to this is the record of Jacobs (1951) for Georgia. In areas of granite and sandstone outcrops in Texas and Oklahoma, and sandstone outcrops of Kansas and Arkansas, the species is quite general distributed, and often is locally abundant. The use of the species by Jacobs (*l. c.*) in his discussion of disjunct ranges, therefore, seems unwarranted.

Howe (1923) gives the size range of spores of this species as 75-108μ but mostly 90-100μ. We find the maximum limit to be 118μ and the lower limit of the range as 70μ. The average spore size, of Kansas material, is 96μ. A few Kansas collections show the outer face of the spore to be somewhat regularly areolate with areoles up to 13.2μ in diameter, as compared to a size of 4-7μ given by Howe. Otherwise Kansas material agrees with the description of the species.

Distribution: *Anderson County:* 1½ miles northeast of Welda,

open sandy prairie, October 31, 1948, R. H. Thompson. *Chautauqua County:* 3 miles northeast of Sedan, sandy soil, oak woods, March 26, 1948, M1212; 3 miles north of Elgin, sandy prairie pasture, April 5, 1952, M5350; 3 miles north of Sedan, sandy soil over surfacing sandstone, April 5, 1952, M5353. *Cherokee County:* 5 miles east of Baxter Springs, rocky clay prairie bank, April 30, 1948, M1354. *Coffey County:* 2 miles southwest of LeRoy, sandy prairie, April 9, 1948, M1240. *Douglas County:* 12 miles south of Lawrence, sandy prairie, April 18, 1948, M1335; October 13, 1951, M5248; 5 miles west of Baldwin City, sandy soil, April 26, 1952, M5435. *Elk County:* 10 miles north of Busby, sandy prairie, April 10, 1948, M1280. *Franklin County:* 1 mile northeast of Norwood, sandy oak woods, March 25, 1948, M1168. *Greenwood County:* 1 mile northeast of Fall River, sandy soil, April 10, 1948, M1289. *Harvey County:* 5 miles north of Burrton, sandy path in sand dunes, June 11, 1951, M4917. *Jefferson County:* 1 mile west of Medina, sandy prairie pasture, April 2, 1948, M1233. *Labette County:* 5 miles southwest of Dennis, sandy soil at edge of oak woods, April 10, 1948, M1267. *Leavenworth County:* 4 miles northeast of Tonganoxie, sandy soil in prairie, May 7, 1948, M1404; 2 miles west of Linwood, sandy soil in oak woods, June 16, 1949, M3087. *Montgomery County:* 3 miles south of Elk City, sandy soil, April 4, 1942, R. H. Thompson; 6 miles south of Elk City, sandy soil in oak woods, March 26, 1948, M1183. *Neosho County:* 2 miles east of Chanute, sandy prairie, April 9, 1948, M1260. *Reno County:* 6 miles northeast of Hutchinson, sandy path in sand dunes, June 11, 1951, M4958. *Wilson County:* 1 mile northeast of Neodesha, sandy soil edge of oak woods, April 10, 1948, M1278. *Woodson County:* 2 miles northwest of Yates Center, sandy prairie, April 9, 1948, M1246; Lake Fegan, sandy soil in oak woods, March 26, 1949, M2649; September 24, 1949, M4125; 2 miles northwest of Yates Center, sandy prairie at edge of oak woods, May 12, 1951, M4810; October 28, 1951, M5278.

60. *Riccia canaliculata* Hoffm. This species is listed here as of questionable taxonomic standing and is based on one collection made in Miami County, Kansas. The plants occurred on soil at the edge of a lake.

As yet no North American specimens of the *Ricciella* section of *Riccia* have been studied, which match the European *R. canaliculata* with the possible exception of a collection by the author from Texas which Müller (personal correspondence) refers to *R. cana-*

liculata. However, Crundwell (personal correspondence) says he has seen no American material which is the same as the European *R. canaliculata.* With this latter statement the writer is inclined to agree.

The Kansas collection under consideration differs from the descriptions of *R. canaliculata* and with European specimens of the species in several ways. The spores have 4-6 areolae across the outer face while *R. canaliculata* has 3-4 and the areolae average 2-4μ smaller in diameter in the Kansas material. The ventral scale cells are similar in the two, although those of our material average 4μ wider and some 10μ longer. The thallus in our plants is more similar to that of *R. duplex* than of *R. canaliculata* though it differs from both in that the compact cells of the ventral half of the thallus has small air chambers. *R. canaliculata* is not known in a water form, while Kansas material readily grows and fruits in water culture as well as on soil.

The present lack of critical study of the species in the *fluitans* complex of the genus *Riccia* makes it difficult to assign the Kansas collection to a suitable taxon. It is, therefore, provisionally assigned to *R. canaliculata* to which it seems to be closely related on the basis of spore characters.

Distribution: *Miami County:* 3 miles east of Fontana, Hugh Whitford Ranch, margin of Pigeon Lake, on soil, April 24, 1948, M1349b.

61. *Riccia dictyospora* Howe. Found in all but the northwestern quarter of the state. It is very common on sandy soil near sandstone outcrops, in sandy prairie, in certain localities in sand dune areas of central and southwest Kansas. It is also to be found on alluvial deposits and on rocky-clay banks. The species is found but rarely on calcareous sites and seems to be restricted almost entirely to sandstone or sandy areas.

This species is extremely xerophytic and survives the most severe drought conditions. In fact, it seems to grow best on open exposed sites which regularly dry up early in the growing season and remain dry until fall rains. During these periods the older parts of the thallus die leaving the tips to begin growth with the advent of moisture.

The determination of Kansas material as *R. dictyospora* was accomplished only after detailed study of the species over its range and after careful study of *R. mcallisteri* Howe. There has been much confusion in the literature as to the proper relationships of these two concepts. We have reached the conclusion that *R.*

mcallisteri is not a valid concept and must be reduced to synonomy under *R. distyospora.*

The characters which have been used to separate the taxa are as follows:

R. mcallisteri	*R. dictyospora*
1. Scales violet.	1. Scales blackish purple.
2. Margins decolorate.	2. Margin narrowly blackish purple.
3. Hypodermal cells in distinct rows.	3. Upper surface reticulate.
4. Spores first violet but finally opaque.	4. Spores brown, rather translucent.
5. Antheridial ostioles elev. 50-160μ.	5. Anth. ostioles elev. 0-50μ.

Comparative studies show that the above characters break down completely when used to attempt species separation. We have studied the type specimens of the two, as well as specimens from the entire range of the taxa and have studied them in the field over much of their range but most importantly in the type locality of *R. mcallisteri.*

It has been observed that the color of ventral scales is a highly variable character in *Riccia's* and such is true with the concepts here considered. We have observed the same colony of these plants over several seasons and have noted that in dry seasons they exhibit scale color of *R. dictyospora* and in more moist seasons the color as given for *R. mcallisteri.* The same statement applies to color of the thallus margin. In the type locality of *R. mcallisteri* (Granite Mountain Texas) we have observed plants growing on the sandy margin of water holes, left by quarrying granite, which had violet scales. As one moved away from the moist environment a progressive change in scale color from violet to blackish purple was found. The margin of the thallus exhibited the same transition. Even the type collection of *R. mcallisteri* exhibits variation in these colorings.

The arrangement of the cells on the upper surface has been used as a key character by Frye and Clark (1937-1947). How such a character came to be recognized is indeed puzzling as type specimens and thousands of specimens seen in the field fail to show any such distinction. We have yet to see any difference between the two, and find them both to be reticulate, and yet to have cells somewhat aligned in rows.

The question of spore color is also one of confusion. We find the spores of the same colony to vary in color from spring to

fall and from year to year. If a given colony is observed through a season it will be noted that spores are at first yellowish after which they become brown or violet brown and finally may become opaque. Most material which has been identified as *R. dictyospora* show spores to be immature. Howe who described both species apparently did not rely on spore characters too much as collection identified by him as *R. dictyospora* have opaque spores and others with light brown spores were identified as *R. mcallisteri*. The difficulty with spores in this complex seems to be due to the fact that spores mature very slowly, and thus plants which look good for specimen purposes seldom have mature spores. As indicated above the matter of spore color intergrades completely, and is so variable as to be useless as a taxonomic character.

Jacobs (1951) discusses the two species and admits that they are closely akin but states that they are quite separable. He further states that the differences between the two are correlated with habitat, but are associated with habitat preference rather than habitat induction. Apparently Jacobs relies on the presence or absence of the black margin or degree of expression of color to separate the two so-called species. We have studied the species in the field over the entire range of *R. mcallisteri* and over most of the range of *R. dictyospora*. As a result we have failed to verify the statements of Jacobs.

Another factor which has probably led to some confusion is the fact that Howe received specimens from McAllister (from Texas) and grew them in a greenhouse at the New York Botanical Garden after which he described the material as a new species (*R. mcallisteri*). This undoubtedly was somewhat responsible for the views on coloration of the thallus.

Finally, it may be true that some of the variations noted may be, in part, found to be grouped into geographic areas and thus perhaps some subspecific segregation will be necessary. This can only be decided after much more work has been done in the field, in culturing, and in cytological studies.

Distribution: *Allen County:* 5 miles north of Moran, creek bank, October 8, 1948, M2501. *Anderson County:* 4 miles south of Garnett, sandy prairie, October 8, 1948, M2486. *Barton County:* ¼ mile north of Pawnee Rock, sandy prairie, August 30, 1950, M4630. *Bourbon County:* 2 miles south of Uniontown, creek bank, October 8, 1948, M2513. *Brown County:* 5 miles northeast of Hiawatha,

sandy roadside bank, September 7, 1948, M2431. *Chase County:* 1 mile south of Strong City, river bank, November 27, 1948, M2607. *Chautauqua County:* 3 miles east of Sedan, sandy soil, May 1, 1948, M1367; 4 miles south of Sedan, sandy prairie, July 8, 1949, M3372; 1½ miles northeast of Sedan, sandy soil over surfacing sandstone, April 12, 1950, M4202. *Cherokee County:* 5 miles east of Baxter Springs, rocky clay bank, April 30, 1948, M1355. *Clay County:* 5 miles north of Morganville, sandy prairie, August 16, 1951, M5066. *Douglas County:* 2 miles southeast of Baldwin City, creek bank, October 11, 1947, M1099; 12 miles south of Lawrence, sandy prairie, April 18, 1948, M1339; 5 miles west of Baldwin City, sandy soil over surfacing sandstone, June 18, 1949, M3103; September 16, 1950, M4674; August 2, 1951, M5004; October 13, 1951, M5247; 2 miles north of Lawrence, river bank, June 12, 1952, M5606. *Elk County:* 10 miles north of Busby, sandy prairie, April 10, 1948, M1279; July 27, 1948, M1916. *Ellsworth County:* sandy prairie, 6 miles southeast of Kanopolis, sandy prairie bank, May 3, 1952, M5453. *Franklin County:* 4 miles southwest of Ottawa, sandy prairie pasture, June 18, 1949, M3096; May 12, 1950, M4247. *Greenwood County:* 6 miles north of Fall River, sandy soil in oak woods, July 27, 1948, M1912; 1 mile east of Fall River, sandy prairie, July 9, 1949, M3406. *Harper County:* 1 mile west of Danville, moist sandy roadside ditch, August 18, 1948, M2234, M2236. *Harvey County:* 5 miles north of Burrton, on sandy soil at edge of pond in sand dunes, June 11, 1951, M4916; July 24, 1949, M3506; August 25, 1951, M5083. *Jefferson County:* 1 mile east of Williamstown, sandy prairie bank, November 6, 1948, M2569. *Kiowa County:* 5 miles east of Greensburg, roadside ditch, August 17, 1950, Olin Fearing 543, 544. *Leavenworth County:* 4 miles northeast of Tonganoxie, sandy soil edge of oak woods, May 15, 1948, M1438; 2 miles west of Linwood, sandy oak woods, June 16, 1949, M3089. *Lyon County:* 1 mile north of Emporia, river bank, November 16, 1948, M2601. *Marion County:* 1 mile south of Florence, river bank, November 27, 1948, M2612. *Miami County:* 3 miles east of Fontana, river bank, October 19, 1947, M1110. *Montgomery County:* 1 mile south of Independence, sandy soil, April 24, 1942, R. H. Thompson; 4 miles southwest of Elk City, sandy soil in oak woods, September 1, 1948, M2395; September 22, 1951, M5223. *Morris County:* 2 miles north of Council Grove, bank of Neosho River, November 27, 1948, M2617. *Nemaha County:* Nemaha County State Park, sandy clay prairie bank, August 9, 1948, M2017. *Neosho*

County: 2 miles east of Chanute, February 14, 1945, R. H. Thompson; April 9, 1948, M1262. *Reno County:* 6 miles west of Pretty Prairie, sandy roadside bank, August 17, 1948, M2221; 6 miles north of Hutchinson, sandy soil, June 11, 1951, M4957; 2 miles north of Hutchinson, edge of pond in sand dunes, August 25, 1951, M5084. *Rice County:* 1 mile east of Geneseo, sandy prairie, April 30, 1949, M2709. *Saline County:* 2 miles northwest of Brookville, sandy soil in prairie, April 30, 1949, M2690. *Shawnee County:* 7 miles southeast of Topeka, sandy overgrazed prairie pasture, April 23, 1949, M2683. *Stanton County:* 1 mile north of Saunders, sandy prairie, August 28, 1950, M4548. *Sumner County:* 2 miles east of Milan, sandy-clay roadside bank, August 18, 1948, M2240. *Washington County:* 1 mile west of Linn, sandy prairie pasture, August 23, 1947, M1085; 2 miles southwest of Palmer, sandy prairie, May 27, 1948, M4828; August 22, 1952, M5724. *Wilson County:* 1 mile northeast of Neodesha, sandy soil October 25, 1947, M1118; 4 miles north of New Albany, sandy prairie, July 9, 1949, M3402. *Woodson County:* 2 miles northwest of Yates Center, sandy prairie, April 9, 1948, September 1, 1951, R. H. Thompson; October 28, 1951, M5281. *Wyandotte County:* 1 mile northeast of Bonner Springs, sandy prairie bank, May 15, 1948, M1441.

62. *Riccia fluitans* L. Rare. Found in two places in Miami County. In both places the plants were found in small lakes in the Marais des Cygnes River valley. Specimens have been taken from water and from mud banks of these stations. Our specimens agree in every respect with the description of the species given by Müller (1952).

Distribution: *Linn Co.:* 2 miles west of La Cygne, in water, June 4, 1959, M2856. *Miami County:* 3 miles east of Fontana, in Pigeon Lake, May 29, 1949, M2773; mud bank of Pigeon Lake, October 8, 1950, M4679; October 27, 1950, M4696; November 30, 1951, M5293.

63. *Riccia frostii* Aust. A common and often abundant species on stream banks, flood plains, and lake shores. It is to be found in all of Kansas except the southwest quarter where it seems to be entirely absent.

One of the remarkable features of this species is the abundance of the plants to be found on alluvial deposits left by major floods of the Kansas River. McGregor (1952) reported the occurrence of this species on silt deposits after the record breaking flood of 1951. It was found that silt covered fields in the river valley con-

tained an average of 1,699,202 rosettes per acre. Hundreds of square miles of the river valley had plants in incredible numbers following the flood. Houses and other buildings which had been filled with a few feet of silt soon had the surfaces of such deposits dotted with young rosettes of *R. frostii.*

Our collections of this species seems to agree very well with published descriptions and with specimens studied from other areas.

Distribution: *Atchison County:* ½ mile south of Muscotah, bank of Little Grasshopper Creek, October 18, 1947, M1103. *Barton County:* 4 miles southeast of Great Bend, bank of Arkansas River, September 4, 1949, M3950. *Chase County:* 1 mile south of Strong City, bank of Cottonwood River, November 27, 1948, M2603. *Cheyenne County:* 1 mile southwest of St. Francis, bank of Republican River, August 28, 1947, M1088; August 13, 1948, M2144. *Clay County:* south edge of Clay Center, bank of Republican River, August 22, 1947, M1084. *Coffey County:* 2 miles north of Burlington, bank of Neosho River, November 26, 1948, M2595. *Decatur County:* Decatur County State Park No. 2, bank of Sappa Creek, August 12, 1948, M2107. *Douglas County:* 1 mile northwest of Lawrence, bank of Kansas River, September 27, 1947, M1092; November 6, 1948, M2568; September 5, 1951, M5216; 2 miles northeast of Lawrence, flooded corn field, August 9, 1952, M5685. *Ford County:* 7 miles northeast of Dodge City, creek bank, September 5, 1949, M3976. *Franklin County:* 1 mile north of Norwood, creek bank, June 19, 1948, M1583. *Geary County:* Milford, alluvial deposit, sandbar in Republican River, August 22, 1947, M1083. *Hodgeman County:* 5 miles east of Grayling, creek bank, September 5, 1949, M3963. *Jackson County:* ½ mile east of Holton, creek bank, August 9, 1948, M2001. *Jefferson County:* 1 mile south of Williamstown, bank of Kansas River, September 28, 1947, M1096. *Johnson County:* ½ mile north of DeSoto, bank of Kansas River, September 27, 1947, M1095. *Labette County:* 4 miles northwest of Chetopa, creek bank, July 2, 1948, M1614. *Leavenworth County:* 5 miles northwest of Tonganoxie, bed of dry lake, August 2, 1947, M1081; ½ mile south of Linwood, bank of Kansas River, September 27, 1947, M1093. *Lincoln County:* 1 mile south of Lincoln, bank of Saline River, July 29, 1952, M5671. *Logan County:* 1 mile west of Elkadeer, bank of Smoky Hill River, August 29, 1947, M1090. *Lyon County:* 1 mile north of Emporia, bank of Neosho River, November 26, 1948, M2600. *Marion County:* 1 mile south of Florence, bank of Cottonwood River, November 27, 1948, M2609. *Marshall County:*

½ mile east of Blue Rapids, bank of Blue River, August 9, 1948, M2036. *Miami County:* Miami County State Park, edge of lake, October 19, 1947, M1108; October 3, 1948, M2473. *Morris County:* 2 miles north of Council Grove, bank of Neosho River, November 27, 1948, M2614. *Norton County:* 1 mile west of Calvert, bank of Prairie Dog Creek, August 12, 1948, M2102. *Ottawa County:* 1 mile south of Bennington, bank of Solomon River, July 29, 1952, M5670. *Pawnee County:* 1 mile west of Larned, creek bank, September 5, 1949, M3960. *Pottawatomie County:* St. George, bank of Kansas River, August 22, 1947, M1082. *Rawlins County:* 6 miles south of Atwood, bank of Beaver Creek, August 13, 1948, M2141. *Republic County:* Scandia, bank of Republican River, August 24, 1947, M1087; August 1953, W. H. Horr. *Riley County:* Manhattan, bank of Kansas River, October 22, 1948, Travis Brooks. *Rooks County:* Stockton, bank of Solomon River, August 27, 1947, M1089. *Russell County:* 1 mile south of Lucas, bank of Wolf Creek, July 29, 1952, M5684. *Saline County:* Salina, bank of Smoky Hill River, August 30, 1947, M1091. *Sedgwick County:* west edge of Derby, bank of Arkansas River, November 26, 1953, M7522. *Shawnee County:* 6 miles east of Topeka, bank of Kansas River, September 28, 1947, M1097; 1 mile north of Topeka, bank of Soldier Creek, October 12, 1947, M1102. *Sherman County:* 12 miles southwest of Goodland, bank of Smoky Hill River, September 5, 1951, M5216. *Smith County:* ½ mile south of Claudell, bank of Solomon River, August 11, 1948, M2094. *Washington County:* 1 mile west of Linn, creek bank, August 23, 1947, M1351. *Wilson County:* 2 miles northwest of Neodesha, bank of Fall River, October 26, 1947, M1123. *Woodson County:* 2 miles northwest of Yates Center, creek bank, September 25, 1948, M2460. *Wyandotte County:* Bonner Springs, bank of Kansas River, September 27, 1947, M1094; September, 1951, O. F. Fearing.

64. *Riccia hirta* (Aust.) Underw. Common on sandy soils in prairie, over surfacing sandstone, and alluvial deposits below such areas. It is rarely found on calcareous sites and never in close association with limestone outcrops.

This species occurs most frequently as gregarious colonies or scattered rosettes on dry, exposed sandy locations. It is an extreme xerophyte and regularly rolls up in early summer and remains dormant until fall rains come when it begins growth again. Mature sporangia are found in late fall, through the winter, and in early spring.

R. hirta is one of the more variable species of hepatics in this area. The variations in ciliation, length-width-thickness ratios, and color are exceptional. Spore characters also show variations which apparently have not been recorded. Several colonies of *R. hirta* have been studied during eight successive seasons and the degree of variation noted.

One striking variation concerns the occurrence of marginal cilia. Usually marginal cilia are present and most abundant near the apex and become fewer in number toward the basal end. In some specimens cilia are very dense, 30-120μ long, slender, and pointed. In others cilia are nearly absent, 30-60μ long, stout, and obtuse. A few collections show numerous cilia on the dorsal surface.

The usual color of this species is glaucous-green to blue-green fading to whitish upon drying on the dorsal surface while the sides are concolorous to purplish. Ventral scales are usually purplish but may be hyaline or whitish. In some specimens, from more xeric sites, the dorsal surface of the thallus has a blue-green or slate colored surface and blackish purple lateral sides.

Spores of Kansas *R. hirta* vary from 82-171μ and have areoles varying from 6.6μ-20μ. The measurements usually expressed in the literature are 90-135μ and 10-13μ for spore and areole size respectively. The inner faces of spores vary from an appearance exactly like that of the outer face to definitely less strongly areolate to irregularly areolate.

The above mentioned variations have been found in the same colonies. The strongly ciliate, darker pigmented, larger spore size is correlated with dry seasons and drier periods within a season though in a given station all variations may be encountered in an area one meter square. The statements just made would indicate that material in central Kansas would tend to show variations in line with that stated for drier situations. Such is true and, unless caution was used, might lead to unnecessary taxonomic segregations.

This latter difficulty seems to be apparent in a paper by Jacobs (1949) in which he described two new species of *Riccia* which, to the writer, seem to be no more than ecological variations of *R. hirta* as found in sandstone areas of Kansas and the granite outcrop areas in the Edwards Plateau of Texas.

The first of these two species described by Jacobs (*l. c.*) is *Riccia tenella* which seems to be a gregarious form of *R. hirta* that occurs on shallow sandy soil over surfacing sandstone or granite outcrops,

in full sunlight—a habitat which readily dries out. Such sites also become moist quickly after slight rains causing the plants to grow for a time, become dormant awhile, and then repeat the process. Such growth has been observed in several stations in Kansas and invariably resultant plants match perfectly the description given of *R. tenella.* These plants typically lack cilia, have a nongibbose dorsal surface, longer terminal segments which are linear. These are characters used by Jacobs to distinguish *R. tenella* from *R. hirta.* Other characters, mentioned by Jacobs fall within normal range of variation to be found in R. *hirta.* Through the courtesy of Dr. D. L. Jacobs, specimens of *R. tenella* were obtained from the type locality (Jacobs 1251). A study of these specimens reveals that they are near exact duplicates of the variations of *R. hirta* mentioned above. Jacobs further compares *R. tenella* with *R. nigrella,* a comparison which is pointless to one who has seen specimens of the latter species. A number of Kansas specimens fit the description of *R. tenella* but since it is only an ecological variant of *R. hirta* it seems best to consider *R. tenella* as a synonym of *hirta.*

The second species described by Jacobs (1949) is *R. eldeeniae,* likewise an ecological form of *R. hirta.* Supposedly *R. eldeeniae* differs from *hirta* in having smaller areolae, smaller spores with both outer and inner face similarly sculptured. Those differences are to be found within a single colony of *R. hirta. R. eldeeniae* was described as having dorsal and marginal cilia. Such characters are also known in several collections of *R. hirta* and all other characters used to separate *R. eldeeniae* from *R. hirta* likewise fail. A collection of *R. eldeeniae* (Jacobs 920) has been made available for study by Dr. Jacobs. We find the specimens to be a variation of *R. hirta* as mentioned above. It thus seems that *R. eldeeniae* must be reduced to a synonym of *R. hirta.*

From the above it is noted that *R. hirta* is indeed a variable species. A detailed study of the taxon in Kansas and from stations in Arkansas, Oklahoma, Louisiana, and Texas indicates that the same variations occur in those areas. Only a careful cytological study coupled with detailed field and cultural studies will show whether taxonomic segregations are necessary. Our studies indicate that this must be done over the complete range of the species as now known.

Distribution: *Allen County:* 5 miles north of Moran, creek bank, October 8, 1948, M2502. *Anderson County:* 5 miles south of Garnett, creek bank, October 8, 1948, M2487; 1½ miles northeast of

Welda, open places in prairie, October 31, 1948, R. H. Thompson. *Brown County:* 5 miles northeast of Hiawatha, sandy roadside bank, September 7, 1948, M2433. *Chautauqua County:* 3 miles northeast of Sedan, sandy soil over sandstone outcrop, March 26, 1948, M1211; 4 miles south of Sedan, sandy prairie, July 8, 1949, M3371; 3 miles north of Elgin, sandy prairie pasture, April 5, 1952, M5349. *Cherokee County:* 5 miles east of Baxter Springs, sandy-clay soil, edge of oak woods, April 30, 1948, M1364. *Clay County:* 5 miles north of Morganville, sandy prairie, August 16, 1951, M5067. *Coffey County:* 2 miles southwest of Le Roy, sandy prairie, April 9, 1948, M1237. *Douglas County:* 1 mile southeast of Lawrence, sandy soil, May 24, 1942, R. H. Thompson; 2 miles southeast of Baldwin City, sandy soil, edge of pond, October 11, 1947, M1098; 5 miles west of Baldwin City, sandy prairie, November 16, 1947, M1138; October 15, 1949, M4144; August 2, 1951, M5005; October 13, 1951, M5244. *Elk County:* 10 miles north of Busby, sandy prairie, April 10, 1948, M1282. *Ellsworth County:* 5 miles east of Carneiro, sandy soil, outcrop in prairie, April 30, 1949, M2698; 2 miles northwest of Langley, sandy soil over outcrop, May 3, 1952, M5450. *Franklin County:* 1 mile northeast of Norwood, sandy prairie, March 25, 1948, M1166. *Greenwood County:* Severy, sandy soil, September 2, 1945, R. H. Thompson; 1 mile north of Fall River, margin of sandstone outcrop, April 10, 1948, M1296; April 13, 1949, M2672; July 9, 1949, M3407. *Harvey County:* 5 miles north of Burrton, cattle trail in sand dunes, June 1, 1951, M4916. *Jefferson County:* 1 mile east of Williamstown, sandy soil in pasture, November 6, 1948, M2570. *Johnson County:* 5 miles west of Olathe, sandy bank, November 2, 1947, M1129. *Kingman County:* 6 miles northwest of Kingman, sandy roadside bank, August 7, 1948, M2226. *Kiowa County:* Rezeau Ranch, sandy prairie, June 12, 1951, M4922. *Labette County:* 5 miles southwest of Dennis, sandy bank, April 10, 1948, M1263. *Leavenworth County:* Military Reservation, October 22, 1942, R. H. Thompson; 1 mile west of Turkey Creek Station, sandy bank, December 2, 1947, M1143. *Miami County:* 3 miles east of Fontana, river bank, October 19, 1947, M1109. *Montgomery County:* 3 miles south of Elk City, sandy soil, April 4, 1942, R. H. Thompson; October 25, 1947, M1122; September 22, 1951, M5233. *Neosho County:* east of Chanute, sandy soil, February 14, 1945, R. H. Thompson. *Shawnee County:* 7 miles southeast of Topeka, sandy clay prairie, April 23, 1949, M2684. *Wabaunsee County:* 5 miles northwest of Paxico, at base of granite glacial drift boulders, June 25, 1950, M4370. *Washington County:* 1 mile west

of Linn, sandy prairie, August 23, 1947, M1352; 1 mile northeast of Linn, sandy prairie bank, August 21, 1951, M5071, M5072; August 22, 1952, M5720; 1 mile west of Linn, sandy alluvial deposit, August 22, 1952, M5724. *Wilson County:* 1 mile northeast of Neodesha, sandy soil, edge of outcrop, October 25, 1947, M1117; 4 miles north of New Albany, sandy pockets in surfacing sandstone, July 9, 1949, M2403; 1 mile east of Neodesha, sandy ledge, April 5, 1952, M5332. *Woodson County:* 2 miles northwest of Yates Center, sandy oak woods, October 26, 1947, M1126; Lake Fegan, shallow soil over surfacing sandstone, September 24, 1949, M4127; 2 miles northwest of Yates Center, sandy soil, edge of sandstone outcrop, May 12, 1951, M4809; 14 miles southwest of Yates Center, sandy soil, September 1, 1951, R. H. Thompson; October 28, 1951, M5282.

65. *Riccia lamellosa* Raddi. A species found in the eastern third of Kansas where it occurs most commonly on sandy soil in prairies, near sandstone outcrops and moist sandy-clay banks. It will tolerate calcareous sites and has been found as rare rosettes on black soil over surfacing limestone in oak-hickory woods.

In late fall and early spring this species appears as rosettes or in gregarious colonies. During summer or dry seasons it is found as rare dichotomies of small size but otherwise is absent. It does not seem to withstand prolonged drought as it apparently does in Oklahoma and Texas.

Our studies on this species in Kansas verifies the action of Müller (1952) in which he reduces *R. austini* Steph. to a synonym of *R. lamellosa* Raddi. We fail to find a single character which consistently could be used to separate American material from the European *R. lamellosa.* The size of the ventral scale in particular is a rather variable feature and is determined by ecological conditions.

Distribution: *Anderson County:* 1½ miles northeast of Welda, open places in prairie, October 31, 1948, R. H. Thompson. *Chase County:* 1 mile south of Strong City, bank of Cottonwood River, November 27, 1948, M2606. *Chautauqua County:* 3 miles northeast of Sedan, sandy soil, oak woods, March 26, 1948, M1210; 3 miles north of Elgin, sandy prairie pasture, April 5, 1952, M5351. *Cherokee County:* 3 miles southeast of Baxter Springs, rocky pasture, October 22, 1951, M5263a. *Clay County:* 5 miles north of Morganville, sandy prairie, August 16, 1951, M5065. *Douglas County:* 1 mile southeast of Haskell, sandy soil, May 7, 1942, R. H. Thompson; 3 miles southeast of Baldwin City, sandy soil over sandstone ledge, November 2, 1947, M1132; 5 miles west of Baldwin City, sandy soil

over surfacing sandstone, November 16, 1947, M1139; October 13, 1951, M5245. *Elk County:* 10 miles north of Busby, sandy prairie, April 10, 1948, M1281. *Ellsworth County:* 4 miles northwest of Langley, sandy soil over surfacing sandstone, May 3, 1952, M5449. *Greenwood County:* 1 mile northeast of Fall River, sandy soil, April 10, 1948, M1297. *Jefferson County:* 1 mile west of Medina, sandy prairie bank, November 16, 1947, M1134. *Johnson County:* 5 miles west of Olathe, black soil over surfacing limestone, November 2, 1947, M1131. *Leavenworth County:* 2 miles west of Linwood, sandy soil, oak woods, June 16, 1949, M3088. *Lyon County:* 1 mile north of Emporia, bank of Neosho River, November 26, 1948, M2598. *Marion County:* 1 mile south of Florence, bank of Cottonwood River, November 27, 1948, M2611. *McPherson County:* 2 miles northwest of Lindsborg, sandy prairie, May 3, 1952, M5439. *Miami County:* 3 miles east of Fontana, river bank, October 19, 1947, M1113. *Montgomery County:* 3 miles southwest of Elk City, sandy bank, October 25, 1947, M1121; sandy soil over surfacing sandstone, September 22, 1951, M5231. *Morris County:* 2 miles north of Council Grove, bank of Neosho River, November 27, 1948, M2616. *Neosho County:* 2 miles east of Chanute, sandy bank, November 27, 1947, M1140; sandy soil around Santa Fe Pond, October 30, 1948, R. H. Thompson; 3 miles east of Chanute, sandy soil, May 12, 1951, R. H. Thompson. *Shawnee County:* 5 miles east of Topeka, soil over surfacing limestone, April 23, 1949, M2678. *Washington County:* 1 mile west of Linn, sandy prairie bank, August 10, 1948, M2046; 2 miles southwest of Palmer, sandy prairie, May 27, 1951, M4827; 2 miles northeast of Linn, sandy prairie, August 22, 1952, M5719. *Wilson County:* 1 mile northeast of Neodesha, sandy soil over surfacing sandstone, October 25, 1947, M1116. *Woodson County:* 2 miles northwest of Yates Center, sandy soil, October 26, 1947, M1127; Lake Fegan, sandy prairie bank, September 24, 1949, M4128; 2 miles northwest of Yates Center, sandy soil over surfacing sandstone, May 12, 1951, M4808.

66. *Riccia rhenana* Lorbeer. This species was first reported from North America and Kansas by McGregor (1952). In Kansas the species has a scattered distribution but seems to grow in most abundance in water below springs or in cattail-sedge marshes.

Kansas specimens exhibit all the characteristics described for the species and match European material of the taxon. It has been found in water and as strand plants, but never produces reproductive structures. This makes its survival in our cattail-sedge marshes

a matter of interest as they often dry up completely and for long periods of time. However, *R. rhenana* makes its appearance soon after such marshes are refilled. It has been observed that the apices of the plants resist rather severe dessication and this may account for survival and spread by waterfowl.

Distribution: *Douglas County:* 2 miles northeast of Lawrence, on mud, edge of cattail-sedge marsh, May 9, 1948, R. H. Thompson; 1 mile northeast of Lawrence, in water, marsh, August 27, 1949, M3894; 3 miles northeast of Lawrence, in cattail-sedge marsh, November 6, 1949, R. H. Thompson; November 13, 1949, M4162; September 23, 1950, M4677; November 30, 1951, M5294; May 8, 1952, M5461. *Jefferson County:* 3 miles west of Williamstown, marsh in Kansas River Valley, November 13, 1949, M4164. *Kiowa County:* 5 miles north of Belvidere, in water below a spring, June 12, 1951, M4921. *Linn County:* 2 miles west of La Cygne, in cattail-sedge marsh, June 4, 1949, M2857. *Meade County:* Meade County State Park, in pond fed by artesian water, May 8, 1942, W. H. Horr; May 16, 1948, W. H. Horr 3111; August 16, 1948, M2199. *Miami County:* Pigeon Lake, shallow water, March 16, 1947, M1056; April 24, 1948, M1349; May 29, 1949, M2774.

67. *Riccia sorocarpa* Bisch. A rather uncommon species in Kansas and never found in any abundance. It occurs on sandy soil in prairie, borders of sandstone outcrops, and alluvial deposits. This species is essentially an early spring plant, disappearing during the summer, but found again in the late fall. It is the first species of *Riccia* to disappear as the various stations dry out and thus is mesic in its requirements.

Kansas material never seems to branch more than once and thus appears as scattered dichotomies which fruit abundantly but do not develop into gregarious colonies. Otherwise our material seems typical of the species.

Distribution: *Anderson County:* 2 miles south of Garnett, sandy-clay soil, open places in oak-hickory woods, June 4, 1951, M4875. *Chautauqua County:* 3 miles northeast of Sedan, sandy prairie, March 26, 1948, M1219. *Cherokee County:* 5 miles east of Baxter Springs, creek bank, October 22, 1951, M5258. *Clay County:* 5 miles north of Morganville, sandy prairie, August 16, 1951. *Crawford County:* 2 miles west of Hepler, field, May 1, 1948, L. J. Gier 1073. *Douglas County:* University of Kansas campus, May 26, 1942, R. H. Thompson. *Leavenworth County:* 4 miles northeast of Tonganoxie, sandy bank, May 7, 1948, M1403. *Montgomery*

County: 3 miles south of Elk City, sandy soil, April 4, 1942, R. H. Thompson; 6 miles south of Elk City, sandy soil, oak woods, March 26, 1948, M1220. *Neosho County:* 3 miles east of Chanute, sandy soil, May 12, 1951, R. H. Thompson. *Shawnee County:* 7 miles southeast of Topeka, sandy soil, overgrazed prairie pasture, April 23, 1949, M2685.

68. *Riccia sullivantii* Aust. Infrequent on alluvial deposits along streams in the eastern fourth of Kansas. It is not abundant nor is it to be found in successive years in the same stations. The species occurs in late fall, usually after fall rains, thus the length of its growing season is curtailed and mature sporangia rarely develop. Kansas appears to be the western limit of the range of this species.

Distribution: *Allen County:* 5 miles south of Moran, bank of stream, October 8, 1948, M2500. *Anderson County:* 4 miles south of Garnett, alluvial deposit, creek bank, October 8, 1948, M2483. *Atchison County:* ½ mile south of Muscotah, alluvial deposit along Little Grasshopper Creek, October 18, 1947, M1104. *Bourbon County:* 1 mile south of Uniontown, bank of Marmaton River, October 8, 1948, M2516. *Cherokee County:* 5 miles east of Baxter Springs, alluvial deposit, bank of Shoal Creek, August 30, 1948, M2355, M2367; October 22, 1951, M5264. *Douglas County:* 2 miles northeast of Lawrence, bank of Mud Creek, September 26, 1948, M2462. *Leavenworth County:* 2 miles north of Leavenworth, bank of Missouri River, October 28, 1948, M2563. *Miami County:* 3 miles east of Fontana, bank of Marais des Cygne River, October 19, 1947, M1111; October 3, 1948, M2468; October 18, 1950, M4680.

69. *Riccia trichocarpa* Howe. Limited to occurrence on sandy soil near surfacing sandstone in prairie or oak-hickory woods. The species is an extreme xerophyte and is to be found on the driest, exposed sandy stations.

Distribution: *Chautauqua County:* 3 miles northeast of Sedan, on sandy soil in oak-hickory woods, March 26, 1948, M1213. *Douglas County:* 5 miles west of Baldwin City, sandy soil near sandstone outcrop, November 16, 1947, M1137; November 7, 1948, M2575; October 15, 1949, M4145; March 30, 1952, M5326; April 26, 1952, M5433. *Elk County:* 10 miles north of Busby, sandy soil in oak woods, April 10, 1948, M1285. *Franklin County:* 1 mile northeast of Norwood, sandy soil, March 25, 1948, M1167. *Greenwood County:* 1 mile northeast of Fall River, sandy soil in oak woods, April 10, 1948, M1290. *Montgomery County:* 3 miles southwest of Elk City, sandy soil near sandstone outcrop, October 25, 1948, M1120; 6 miles south

of Elk City, sandy soil in oak woods, March 26, 1948, M1184; 3 miles southwest of Elk City, sandy prairie, September 22, 1951, M5235. *Wilson County:* 1 mile northeast of Neodesha, sandy soil near sandstone outcrop, April 10, 1948, M1273. *Woodson County:* 2 miles northwest of Yates Center, sandy soil in Prairie, October 26, 1947, M1125; April 9, 1948, M1245; May 12, 1951, M4811; October 28, 1951, M5279.

Excluded Species

A few species have been reported in the literature as present in Kansas for which specimen evidence is not known. Such reports were probably based on incorrect determinations as it seems unlikely that some of them could occur in the State. All were listed by Smyth and Smyth (1911) and are as follows:

1. *Chiloscyphus polyanthus* (L.) Corda.
2. *Fossombronia angulosa* Raddi.
3. *Jungermannia schraderi* Martius.
4. *Leucolejeunea clypeata* (Schweinitz) Evans.
5. *Pallavicinia lyellii* Gray.
6. *Pellia endiviaefolia* (Dicks) Dum.
7. *Preissia quadrata* (Scop.) Nees.
8. *Ptilidium ciliare* (L.) Hampe.
9. *Riccardia latifrons* Lindb.

ECOLOGICAL STUDIES

Location and Area

Kansas is located in the center of the United States and has a generally rectangular shape. The north and south boundaries are the parallels of 40°N. and 37°N., respectively; the eastern boundary is the Missouri River and 94°38′ W.; and the western boundary is 102°1′34″W. This area—about 210 miles north-south and 410 miles east-west—contains an area of about 82,000 square miles.

Climate of Kansas

It is necessary to preface a discussion of ecology in Kansas by considering the recorded data on temperature, moisture, winds, etc. The present discussion of climate in Kansas is based directly on the publication of Flora (1948) and supplemented observations of the writer.

As a whole the State has an annual mean temperature of 55°F, almost equal to that of Virginia, more sunshine than any state to the east, and summer rains which average, in eastern counties, higher than those of other states except those along the Gulf Coast.

This combination of weather elements makes the State a leading agricultural region for grains and livestock, but tends to restrict the development of a hepatic flora which a consideration of weather elements will show. The 400 mile spread of the State from east to west results in three areas having rather distinct climates which may be designated as eastern, middle, and western.

Rainfall: Rainfall varies from an average of nearly 36 inches in the eastern third of the State, to about 26.5 in. in middle, and to 19 inches in the western third. This rainfall is often not equally distributed during the season with a result that prolonged dry periods, such as occurred in 1952-53, may affect the flora more than the long term averages would lead one to suspect.

Humidity: The average relative humidity over Kansas is less than in any state east of the continental divide of the Rockies. Average midday and evening humidities over the State in July range from 30-40 per cent in the western part to 45-50 per cent in the eastern part. This low relative humidity allows for rapid evaporation and drying out of most of the habitats in the State. This has a profound effect on Hepaticae.

Temperatures: As noted previously Kansas has a mean annual temperature of 55°F. The warmest month of the year is July with an average mean temperature of 79°F and the coldest is January with an average mean of 30°F. The lowest temperature ever recorded officially in the State was 40°F below zero and occurred in north-central Kansas. The highest official temperature was recorded in the southeastern part of the State at 121°F.

Winds: The prevailing direction of wind in all parts of the State is from the south and southwest, April to November, inclusive. In other months northerly winds prevail. In eastern Kansas winds have an average hourly movement of 9 miles while they average 12 miles in southwest Kansas.

An outstanding effect of wind occurs occasionally during the course of hot summer weather. At such times winds of rather high velocity, low relative humidity, and with shade temperatures of 100-110°F or higher have been known to kill foliage and destroy growing crops. These are the "hot winds" which the writer has observed to kill a corn crop in one day's time.

Frosts: The average last date for killing spring frosts ranges from April 9 in extreme southeastern Kansas to May 2 in the extreme northwestern part of the State. However, killing frosts have been

known to occur as late as the second week of May in southeastern Kansas and in the last week of May in extreme northern counties.

The average date of first killing frost is the first week in October in northwestern Kansas to the last week of October in the southeast. Killing frosts have been known in the first week of September in the northwest to the third week of September along the southern border.

The climate of Kansas is, then, one of great extremes and sudden changes in temperature, precipitation, and wind. Conditions at any one point may vary widely from year to year and very often are extremely unsatisfactory for vegetation. It must be emphasized that it is the extremes of climate which most affect the occurrence and distribution of hepatics in the State, rather than the average which at first glance might seem to be favorable for a more diverse vegetation including liverworts.

VEGETATION AREAS IN KANSAS [1]

Studies on the vegetation of Kansas during the past 100 years have been concerned mainly with attempts to obtain a complete record of all species found to occur in the area. Numerous publications have been produced which give lists of species and counties where such species have been found. As yet no one has made a serious attempt to delimit and define vegetative areas in Kansas. It is true that, as yet, insufficient field studies have been made and thus it is not possible to prepare a map of vegetation areas which would show more than broad generalizations.

A few publications have included discussions and maps which involve vegetation areas to some extent. Some of these are Brumwell (1941), Cockrum (1952), Fearing (1952), and Gates (1937, 1940). All of these have contributed to our knowledge of vegetative areas either directly or indirectly but none have been close to adequately portraying the true nature of vegetation assemblages in Kansas.

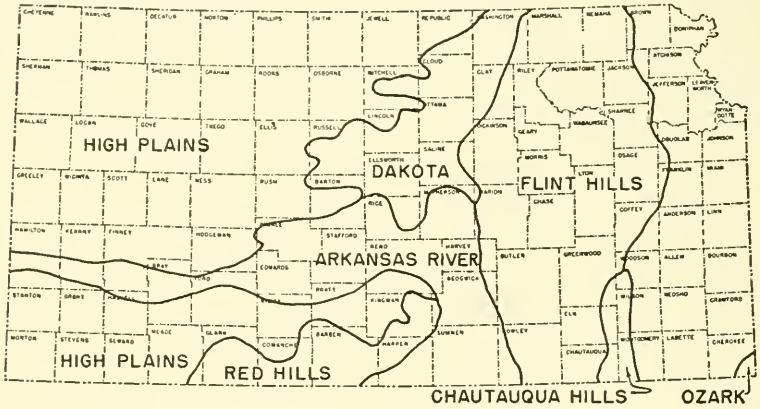
Since none of the previously published accounts of vegetation areas in Kansas seem to be of much value, the writer here presents, as map 1, a break-down of the major vegetation areas in Kansas. In preparing this map it was not intended that it show all minor zones or deal with the complexities of the numerous transition areas. The map is based on the writer's studies, made in each county of the State, of the distribution of bryophytes and all higher

1. Information on the Physiography of Kansas adapted from Schoewe (1949).

plant groups. Future studies will, without doubt, alter the boundaries of some areas here proposed.

The small Ozark area in extreme southeastern Kansas is an extension into Kansas of the Springfield Plateau in Missouri and is the edge of a westward dipping plain underlain by limestones of Mississippian age. The area has a relief which averages less than 60 feet, but has a number of bluffs along streams, is rocky, and has outcrops of limestone.

This small Ozark area of some 50 square miles is botanically one of the more interesting parts of the State. More species of



Map I. The map shows vegetation areas in Kansas.

higher plants are known from this area than for any other of equal or larger size in the State. In this area of Kansas a number of eastern and Ozarkian taxa find the western limit of their range. In addition a number of plants common in this Ozark area are found only rarely elsewhere in adjacent vegetation assemblages. Some of the taxa known in Kansas from the Ozark area only are: *Isoetes butleri, Dryopteris hexagonoptera, Saururus cernuus, Arabis laevigata, Asclepias quadrifolia, Ludwigia glandulosa, Polymnia uvedalia, Cornus florida, Ulmus alata, Vaccinium stamineum* var. *interius, Vaccinium vacillans* var. *missouriensis, Hieracium gronovii* and *Aster turbinellus.*

The Ozark area is characterized by oak-hickory wooded hillsides on which the common trees are *Quercus alba, Q. macrocarpa, Q. muehlenbergii, Q. marilandica, Q. shumardii, Q. velutina, Carya cordiformis, C. laciniosa, C. ovata, C. texana, Celtis occidentalis, Ulmus americana, U. rubra,* and *Acer saccharum.* The understory

is dominated by *Symphoricarpos orbiculatus, Aesculus glabra* var. *sargentii, Ostrya virginiana, Staphylea trifolia, Cercis canadensis* and numerous other plants. Among the forested hillsides, hilltops and bluffs are islands of tall grass prairie which are dominated by *Andropogon gerardi, Sorghastrum nutans, Tripsacum dactyloides,* and *Panicum* spp. These prairies often have thickets or marginal bands of *Sassafras albidum, Diospyros virginiana* and *Prunus* spp. A few marshes, streams, and extensive rock outcrops offer a variety of additional habitats for hepatics.

The Osage area includes parts of three physiographic divisions. The southern third is an erosional plain whose surface slopes to the west at an average rate of 10 feet per mile and is developed from weak shales and sandstones. The surface is gently undulating except for a few broad, flat-topped mesalike wooded hills which are capped by resistant sandstone. Some of these hills rise 80 or more feet above the surrounding country. Several wide, shallow, flat bottomed valleys occur. The central section of the Osage consists of a series of northeast-southwest escarpments which face east and between which there are flat, to gently rolling plains. The crest of each escarpment is capped by resistant limestone. These escarpment fronts range from a few feet to more than 200 feet in height. The northern part of the Osage is a glaciated area and for the most part is an erosional drift-controlled surface which is gently undulating. Near large streams the country is dissected into rough and hilly areas with river bluffs too rough for cultivation and revealing ledges of limestone and some sandstone. Interstream areas are smooth, broad, and well rounded and become more dissected as one approaches larger stream courses. Most valleys are wide and open.

The Osage vegetation area consists basically of oak-hickory wooded hillsides, creek valleys, and ravines. Uplands were originally covered with tall-grass prairie dominated by *Andropogon gerardi.* It is an area much disturbed by man and original vegetation is to be found primarily in out-of-the-way places. Woods, in general, are dominated by *Quercus macrocarpa, Q. muehlenbergii, Q. velutina, Carya cordiformis, C. ovata, Ulmus americana, U. rubra* and *Celtis occidentalis.* In some locations significant stands of *Acer saccharum, Tilia americana, Quercus alba, Juglans nigra* and *Fraxinus lanceolata* are found. The understory consists principally of *Symphoricarpos orbiculatus, Ostrya virginiana, Aesculus glabra* var. *sargentii, Asimina triloba,* and *Staphylea trifolia.* Characteristic

herbs are *Podophyllum peltatum, Carex* spp., *Agrimonia* spp., *Sanicula marilandica, Phlox divaricata, Isopyrum biternatum,* and others.

Prairies of the Osage area are dominated by *Andropogon gerardi.* In dry sites *Andropogon scoparius* and *Bouteloua curtipendula* become evident while in moist places *Tripsacum dactyloides, Sorghastrum nutans, Triodia flava* and *Panicum virgatum* may be locally dominant. In all cases species of *Panicum* and *Poa* are usual components. A number of forbs give the prairie seasonal aspects. Some of these are *Baptisia leucophaea, Sisyrinchium campestre, Phlox pilosa, Hypoxis hirsuta, Tradescantia bracteata, Senecio plattensis, Silphium laciniatum, Helianthus spp., Ratibida pinnata, Rudbeckia serotina, Liatris pycnostachya, Solidago* spp., *Aster* spp., *Amorpha canescens, Petalostemum purpureum, Psoralea esculenta, P. tenuiflora* and many others.

A number of streams dissect the Osage area and in the valleys formed the usual *Salix, Populus, Ulmus, Acer* and *Fraxinus* stream bank floristic assemblages are found. In the lower third of this area significant stands of *Quercus palustris* are found in lowland woods.

The Chautauqua Hills include a belt developed on thick sandstones in which erosion has dissected the surface into a series of low hills which are intersected by many small streams which have cut deep valleys. This is an area distinguished primarily by sandy soil and sandstone capped hills whose tops and upper slopes are forested with *Quercus marilandica, Q. stellata, Q. prinoides,* and *Q. velutina.* Along streams and in the northern parts of the area many of the trees of the Osage become admixed with the above. The prairies of the Chautauqua Hills are simliar to those of the Osage except that they occur on sandy soils and those of the latter are predominantly calcareous and thus drier. The sandstones of the Chautauqua Hills extend northeastward to Leavenworth, in Leavenworth County. A few small areas in Douglas, Franklin, Jefferson, Leavenworth and Wyandotte Counties should be considered as isolated elements of the Chautauqua Hills. Jewett (1941) believes that these areas should be so included in the Chautauqua Hills and the hepatic flora corroborates Jewett's opinion.

The Flint Hills area features a range of hills about 20 miles wide extending down the center of the area from Marshall County in the north to Cowley County in the south. The eastern front of these hills has a very prominent rocky escarpment several hundred feet high. This highly dissected east-facing escarpment has ter-

raced rocky slopes. The rocks of the area are limestone which bear flint. The surface of the Flint Hills is gently rolling and merges on the west with a smooth gentle slope toward the Arkansas River. On the east the Flint Hills merge gradually with the Osage area below the escarpment. The streams of the Flint Hills flow in steep precipitous channels lined with rock ledges.

The Flint Hills area is best characterized as a blue-stem grass region. On the uplands and dry places *Andropogon scoparius* is the dominant species while hillsides and moist places are dominated by *Andropogon gerardi. Bouteloua curtipendula* is usually present with both of the bluestems. Forbs are similar to those of the Osage prairies except a larger number of legumes are present. Along the streams are found a limited amount of forests which are tongues or fingerlike projections of the Osage forest through the Chautauqua Hills and from the Osage area of the north into the Flint Hills. Trees found are usually *Ulmus americana, Quercus macrocarpa, Fraxinus lanceolata, Acer negundo, Populus deltoides* and *Salix* spp. The Flint Hills are of little importance in hepatic distribution since species present in the area are few in number, found only on bark or stream banks, and consist of ubiquitous taxa.

The Dakota area consists of a maturely dissected, broad, hilly, belt carved in Dakota sandstone and having a relief at places of from 200-300 feet. Numerous outlying hills and mounds are found. Stream valleys are wide but small tributaries often have abrupt banks with outcroppings of sandstone. These often have springs or are seepy and usually shaded. This area is conspicuous due to the frequent outcroppings of the dark Dakota sandstone. The original vegetation was dominated by the bluestem grasses *Andropogon scoparius* and *Andropogon gerardi* but overgrazing and drought have allowed the more resistant shortgrasses *Buchloe dactyloides* and *Bouteloua* spp. to become dominant and, in severe cases, annual grasses, such as *Hordeum pusillum,* have invaded. Therefore, the Dakota is not stabilized and is mainly one of transition between bluestem on the east and shortgrasses on the west. Forbs also represent a mingling of eastern and western species. No species known in Kansas are confined to this Dakota; but since the area is well defined, has a better soil moisture relationship than areas to the east or west, it does form a discreet vegetation area as noted by Gates (1937). The stream banks and valleys of the Dakota are forested similar to those of the Flint Hills. The numerous sandstone exposures along with sandy soil prairies and the trees, particu-

larly *Quercus macrocarpa,* allows for a hepatic flora which ranks third, behind the Chautauqua Hills and Ozark areas, in number of plants present.

The Arkansas River is a loosely defined area consisting of the Arkansas River valley and associated low, undulating plains along the river and its tributaries. The soil is sandy and vegetation is dominated by sand grasses both along the streams and in the extensive sand dune formations located in the area. Doell (1938) reports that the sand hills of Harvey, Reno and Rice counties are similar to the sand hills westward along the Arkansas River. Doell believes that the sand hills present a true transition between tall and short grass prairies and that stability is never reached. In the Arkansas River both tall and short grass associations are found. The latter are located on drier more stable soil; but the very sandy and sand dune parts, so characteristic of the area, though including plants of both short and tall bluestem grass associations in addition have some distinctive species such as *Calamovilfa gigantea, Andropogon hallii* and *Panicum virgatum* which are found to be locally dominant. The forbs present are also a mixture from other areas but several are found only in the Arkansas River vegetation assemblage. In general the vegetation is xerophytic and grasses are the dominant plant cover with *Salix* spp., *Populus* spp., and thickets of *Prunus* spp. forming the only significant woody components. Hepatics are few in number and are found along cattle trails, through moist sandy pastures, or around bodies of water in dune areas. All are ubiquitous species.

One of the most picturesque areas of Kansas is the Red Hills. It has red soil and outcrops of red shales, silt-stones, sandstones, including gypsum and anhydrite, of Permian age. Barber County is especially scenic with many steep-sided buttes, pinnacles, and stream valleys lined by steep bluffs. Vegetation of this area is xerophytic and the most conspicuous plant, now largely removed, is the red cedar *Juniperus virginiana.* Plant cover is predominantly the short grasses *Buchloe dactyloides* and *Bouteloua gracilis.* A large number of forbs are found, a few of which, are known only in Kansas from the Red Hills. Few mosses and virtually no hepatics are to be found in this area except near springs where conditions are similar to areas in the eastern part of the state.

The High Plains area is also known as the short grass region in which the dominant plants are the short grasses *Buchloe dactyloides* and *Bouteloua gracilis.* Many other distinctive grasses and forbs

occur, some of which are found, in Kansas, only in the High Plains area. This well-defined area is nearly devoid of bryophytes and need not be further considered.

HABITATS AND FACTORS

Very little experimental data concerning environmental factors in relation to bryophytes, especially Hepaticae, is available. With regard to this Garjeanne (1932) says, "Though it is sometimes possible to grow them for shorter or longer periods, in the end they always die: this is certainly a great handicap to gaining a more intimate knowledge of the Bryophytes." This statement while not certainly applicable to all bryophytes is in general true and has handicapped the study of this phase of Bryology.

In the absence of specific experimental data, careful field observations have been made on a variety of habitats and involve transplanting, pH, moisture, temperature, and soil studies. From these a number of generalizations may be made. The discussions of Richards (1932) and Garjeanne (1932) encourage the use of physiological and ecological characteristics which bryophytes have in common with vascular plants and note that factors which affect one group will also affect the others. In our area it is the degree to which such factors affect various plant groups that becomes important.

Moisture conditions of both the substratum and the atmosphere are of prime importance in the growth and survival of hepatics. The occurrence of an abundance of hepatics in a few Kansas sites can be directly correlated with moisture conditions of the substratum and perhaps more importantly with that of the relative humidity of such places.

In most of our areas the majority of species of hepatics are to be found on moist sandstone outcrops, sandy prairie, around and below springs or in shaded protective places which dry out slowly. It is often possible to collect over sections of forested areas and find only a few widely tolerant ubiquitous species. However, in the same terrain on certain outcrops or seepy ledges a larger number of species may be found. If the localized sites are characterized by very seldom drying out, a good hepatic flora will be found. Any prolonged drouth will, however, reduce the colonies and may lead to extermination of certain species.

A study of Kansas hepatics leads one to the conclusion that, except in a few cases, most species are fighting for survival; and that with the disturbance by man, some have probably disappeared from the

scene while others are barely surviving. In contrast disturbance has probably been responsible for an increase in numbers of some species such as members of *Riccia, Sphaerocarpus, Frullania* and *Asterella.*

The only species, in Kansas, which actually live in water are the water forms of *Ricciocarpus natans, Riccia fluitans, R. rhenana,* and possibly the plant provisionally referred to as *Riccia canaliculata.* A few exist on very wet mud banks or alluvium of streams and lakes. Among these are land forms of the four species just mentioned and *Phaeoceros laevis, Notothylas orbicularis, Conocephalum conicum, Marchantia polymorpha, Plectocolea hyalina* and several species of *Riccia.* These latter, however, are present on such sites due to water dispersal and are only temporary elements except for *Riccia frostii* and *R. sullivantii.*

A few species seem capable of withstanding severe flooding for prolonged periods. These are usually species found on the faces of sandstone outcrops on creek banks. Plants in this class are *Conocephalum conicum, Marchantia polymorpha, Plectocolea laevis, Reboulia hemisphaerica* and *Porella pinnata* which is found on the bark of trees at the edges of streams. In addition *Frullania inflata* has been observed to withstand flooding while growing on the bark of trees found on flood plains.

The only perennial species which seem to be able to survive on substrata which regularly dry out are: *Cephaloziella rubella, C. byssacea, Lophozia bicrenata, Mannia fragrans, Asterella tenella, Oxymitra paleacea* and several species of *Riccia. Scapania nemorosa* is able to survive in a few places where the above occur but actually seems to be losing out on such sites. A few annual species appear on these locations during moist springs or falls. Among these are: *Sphaerocarpus texanus, S. michelii, Fossombronia braziliensis* and *Anthoceros punctatus.*

Most species of hepatics in Kansas occur on sites which are so located that moisture is present the year round and in which the relative humidity is higher than in the surrounding area. Such areas consist of moist outcrops in shaded ravines or along creek banks, shaded, protected north hillsides and at the base of grass clumps in tall grass prairie.

Moisture is, then, a critical controlling factor in the occurrence and distribution of hepatics in Kansas.

Light seems to be another factor to be considered in determining distribution of hepatics; but it is most difficult to evaluate because

of its effect on temperature and humidity. In general light requirements of hepatics are not generally high. This is well shown, in Kansas, in that most hepatics grow in shaded habitats or at least where light is much reduced. In general the *Marchantiales* are light-loving while the rest of the Hepaticae have low light requirements. In general, the more moist the location, the more tolerant our species are of light. It is, therefore, difficult to evaluate the effect of light on liverworts.

The nature of the substratum is another factor important in hepatic occurrence and distribution. Species growing on tree bark are limited to host plants from which the bark does not readily flake or slough off. *Frullania* spp., for instance, regularly are found on bark of *Quercus velutina* and *Q. macrocarpa* but the more abundant *Q. muehlenbergii* has few colonies due to the more loose, flaky bark. If *Q. muehlenbergii* is found in a moist ravine the number of colonies of *Frullania* on this tree increases. Thus, a moisture factor is involved. In this case, however, the flaking of the bark seems to be an important factor as occurrence of species on bark in a given area is directly correlated with permanency of bark. Soft sandstones likewise have a small hepatic flora while resistant sandstones in the same area support a good population.

The nature of the soil is important in distribution. This is often correlated with moisture relationships of the soil. In Kansas better than 90 per cent of soil hepatics are to be found on distinctly sandy sites. These soils have a more permanent moisture supply and better aeration. Cultures have been tried on sandy soil, loam, clay and on mixtures of these. Successful growth has been found only on sandy soils.

A few of our hepatics seem to prefer a nitrogen-free medium. *Cephaloziella rubella* and *Lophozia bicrenata* seem regularly to occur in nitrogen-free sites and seldom are to be found on any other type of habitat. Griggs (1933, 1935) gives a discussion of a nitrogen-free medium by *Cephalozia bicrenata* and *Cephaloziella byssacea.*

The most completely investigated substrate factor is that of hydrogen-ion concentration. A number of observations have been made on a large number of bryophytes and the findings reported in the literature. In Kansas most of our hepatics occur on neutral or just under neutral pH conditions. Distribution does not seem to be related so much to pH as to availability of calcium. Calcium may be easily available under slightly acid conditions and a species may react much more to calcium occurrence than to hydrogen-ion

concentration. Some workers such as Meylan (1924) consider species occurring in conditions with pH less than 7.0 as lacking tolerance for lime containing rock or soil. In our area by far the majority of our species occur on calcareous sandstones or sandy soils in which pH is neutral, slightly acid, or slightly alkaline. If the work of Meylan (*l. c.*) was followed, most of our species would alternately be classed as lime avoiding or lime loving as the site might be. However, the lack of very acid stations undoubtedly limits the hepatic flora of the State as it has been shown by Schuster (1949) that uncommon species often appear very much restricted in occurrence by pH conditions. Thus pH probably has little bearing on the distribution of hepatics now known in Kansas.

Temperature effects on our hepatic distribution is difficult to evaluate because of its effects on humidity and moisture in general. It has been observed that sudden drops of temperature results in death of some members of the Marchantiales. Colonies of *Conocephalum conicum, Reboulia hemisphaerica, Riccia campbelliana* and *Mannia fragrans* are quickly killed back to growing tips by sudden drops in temperature and if the drop goes from temperatures, which have averaged above freezing to a reading of 20° F. or lower, even the growing tips succumb. In general, though, temperature is unimportant in our area except in its effect on moisture conditions—an effect which is often most severe.

Invasion and Succession

Though many species of hepatics seem to be attempting to survive in Kansas habitats, several are capable of not only existing but of invading and some successional stages can be demonstrated. The literature on invasion and succession by Hepaticae is meager and most of it in this country is of more or less recent publication.

Durand (1908), Skutch (1929), Emig (1930), Torrey (1932a, 1932b), Graff (1935, 1936), Sharp (1939), and Schuster (1949) all have noted the invasion of *Marchantia polymorpha* upon areas following fires. This was observed once in Kansas at a station in a forest dominated by *Quercus stellata, Q. marilandica, Q. velutina* and with an understory of *Q. prinoides, Cornus drummondii* and *Rubus* spp. During one fall much of the understory and a few oak trees were cut. The brush and tree branches were piled in a number of heaps over an area several acres in extent and burned. This left several large circular burned places which the next spring were populated by solid growths of *Marchantia polymorpha* and the

moss *Funaria hygrometrica*. The plants of *Marchantia polymorpha* were small, exceptionally fertile and were to be found only on the burned spots. This occurrence was remarkable in that *M. polymorpha* was not previously known near the station and since has not been located near the burned areas. The nearest permanent station was some 25 miles away. The second year following the burning only a few plants of *Marchantia* were present on these burned sites and in following years none were discovered. In the meantime herbs and grasses invaded the circular spots and eventually *Quercus prinoides* dominated the sites.

On a few sandy-clay banks which have been recently eroded, and in which the soil is nearly nitrogen-free an invasion by *Cephaloziella rubella* occurs. In a few sites this species is soon followed by *Lophozia bicrenata*. Various species of *Cladonia* seem to follow these two hepatics closely and eventually lead to occupancy by several species of mosses, later by shrubs, grasses and often by either *Mannia fragrans*, or *Asterella tenella*. Later the hepatics lose out in about the same order as the original succession.

Invasion of moist sandstone ledges is initiated by *Phaeoceros laevis* or *Plectocolea hyalina*. These may exist separately or together and very often appear to maintain their dominance of the site. This latter happening appears most often in places where the site is partially exposed to full sunlight. In more shaded conditions *Reboulia hemisphaerica* may soon appear and in humid shaded places *Conocephalum conicum* may take over and eventually exclude most of the earlier arrivals.

Moist limestone ledges are so rare in Kansas that little in the way of possible invasion—much less in way of succession—can be noted. Dry limestone ledges are plentiful and are colonized by *Frullania inflata* or *Frullania riparia*. Often these two are found as mixed colonies. On the crests of such ledges *Porella platyphylla, P. platyphylloidea*, and very rarely *Porella pinnata* may be found in isolated stations. No other hepatics are regularly found in this habitat and thus succession of hepatics does not occur. A moss succession does obtain; but this is outside of the scope of this paper.

Hepatics found on floodplains are often considered as invaders. The most common hepatic on floodplains, or alluvial deposits along streams is *Riccia frostii*. However, this is the regular habitat of this species and should perhaps be best eliminated from a

list of invaders on such sites. Species which do more or less regularly appear on alluvial deposits other than the above species are: *Riccia beyrichiana, R. sorocarpa, R. hirta, R. bifurca, R. dictyospora, R. lamellosa, R. sullivantii, Notothylas orbicularis, Phaeoceros laevis, Plectocolea hyalina, Marchantia polymorpha* and land forms of *Ricciocarpus natans, Riccia rhenana, R. fluitans* and possibly *R. canaliculata.* These species do appear after the deposits are left but they never last for more than a season, if that long. Such habitats are useful in checking species to be found in a water-shed but other than *Riccia frostii* they are of no importance, ecologically, in this area. The statement of Schuster (1953) that *Riccias* are confined largely to alluvial soils, or areas bordering alluvial soil does not apply in our area for most species of the genus in this country. The same statement has been made for *Notothylas orbicularis* by Schuster (*l. c.*), Sharp (1949), and others but again it is not applicable to Kansas, since it has been noted above the "mother lode" of this species is to be found in the prairie. Except for *Riccia frostii,* the land forms of *Ricciocarpus natans, Riccia fluitans,* and *R. rhenana,* all the above species invade but only temporarily so. The latter four can hardly be considered as invaders since their usual habitat is on alluvial sites.

The invasion of hepatics on tree bark is of regular occurrence and involves, essentially, only the species of the genus *Frullania.* These seem to persist as expanding colonies on tree bark and last as such until crowded out by mosses. No hepatic succession occurs in this area on bark. Other hepatics found on bark are too rare to cite as examples of invasion.

Bryophytes are active in the revegetation af abandoned fields in Kansas, particularly those fields with sandy soils. Mosses are of primary importance but a few hepatics are to be noted. The latter, however, are relatively unimportant and seem to play a more important part in disturbed prairies and woodlands than they do in true revegetation. Species which have been observed on sites undergoing revegetation are: *Riccia beyrichiana, R. dictyospora, R. sorocarpa, Anthoceros punctatus, Asterella tenella, Fossombronia brasiliensis* and *Sphaerocarpus texanus.*

Undisturbed prairie is inhabited by a comparative large number of species. These are well scattered and inconspicuous. The first stages of disturbance, however, results in many small isolated, bare areas which are immediately invaded by several species

of *Riccia* of which the more important are *R. beyrichiana, R. hirta, R. dictyospora, R. campbelliana* and *R. sorocarpa.* These may form single scattered rosettes or more commonly form irregular gregarious colonies which hold soil and help prevent erosion and water loss. Often *Sphaerocarpus texanus, Fossombronia brasiliensis* and *Anthoceros punctatus* form conspicuous secondary invaders. Later small amounts of *Asterella tenella* and *Mannia fragrans* may appear at about the time mosses become evident. The mosses soon gain control, resulting in decline of hepatics and eventual return to the original conditions of near complete grass cover. If the conditions causing disturbance, such as mowing, burning, or grazing remain, the area will continue to exhibit a hepatic flora of many plants. In low moist prairie sites the early invaders may often be *Notothylas orbicularis* and *Anthoceros punctatus.* Such areas are soon dominated by mosses, hepatics are excluded, and bare areas return to normal grass cover.

CORRELATION WITH OTHER VEGETATION

As might be expected the distribution of Hepaticae, in Kansas, is often directly correlated with the occurrence of higher plants. It has been found possible to drive through an area and select stations, based on higher plant associations, which are the most important in hepatic collecting. This fact is shown by a number of tests in which areas were selected on the basis of higher plant assemblages and a prospective list of hepatics for the area was made before collecting was started. Even though such specific areas had never been studied previously it was found that the list of species suspected for the station was invariably 90 per cent or more correct. After much field work had been accomplished it was found that the use of higher plant associations as indicators of spots worth studying proved an efficient method of completing distributional data in little studied counties.

As a result it has been possible to prepare lists of species which are found in the various associations of higher plants in the State.

The oak-hickory association mentioned as occurring in the Chautauqua area contains by far the largest number of hepatic species in Kansas. This association is characteristically dominated by *Quercus stellata, Q. marilandica, Q. velutina, Q. prinoides* and *Carya ovata.* The soil is always sandy and sandstone outcrops are frequent either as ledges or barely surfacing on slopes and hilltops. In such forested areas the hepatic flora is dominated

by members of the Marchantiales and the genus *Riccia* in particular. The following lists indicated the degree of occurrence:

Species invariably found are:

Asterella tenella
Frullania inflata
Riccia beyrichiana
Riccia dictyospora
Riccia hirta
Riccia lamellosa
Sphaerocarpus texanus

Species found, in addition to those above, if site includes dry sandstone ledges or exposed banks are:

Cephaloziella rubella
Lophozia bicrenata
Reboulia hemisphaerica

Species found, in addition to all above, if site includes moist sandstone ledges and banks are:

Conocephalum conicum
Mannia fragrans
Phaeoceros laevis
Plectocolea hyalina
Scapania nemorosa

In the southern third of the Chautauqua Hills the association would nearly always include, in addition to all above, the following:

Fossombronia brasiliensis
Oxymitra paleacea
Riccia campbelliana
Riccia trichocarpa

Species found only in this association but of rare occurrence are:

Jungermannia lanceolata
Plectocolea crenuliformis
Plectocolea fossombronioides
Chiloscyphus pallescens
Chiloscyphus pallescens var. *fragilis*
Scapania irrigua
Cephaloziella byssacea
Cephalozia catenulata
Cephalozia connivens
Cephalozia media
Calypogeia meylani
Calypogeia muelleriana
Calypogeia trichomanis
Plagiochasma rupestre

Bluestem prairie of the Chautauqua Hills is usually sandy and is dominated by *Andropogon gerardi.* Swales may have *Tripsacum dactyloides* or *Sorghastrum nutans* as dominant vegetation. Most of these prairies are either mowed once a year for hay or are grazed. If grazing is well controlled the two uses result in prairie of about the same characteristics. In such prairies, hepatic species usually expected occur.

Species invariably present on flats or hilltops are:

Anthoceros punctatus
Asterella tenella
Riccia beyrichiana
Riccia dictyospora
Riccia hirta
Riccia sorocarpa
Sphaerocarpus texanus

Species found in swales in addition to all above are:

Notothylas orbicularis *Riccia lamellosa*

In southern third of area the following are expected:

Oxymitra paleaca *Riccia trichocarpa*

A number of other species have been found on these prairies but are rare and not of usual occurrence.

In the extreme southeastern corner of Kansas is found a bit of the Ozark Plateau, here referred to as the Ozark area. As mentioned before this area consists of rocky, oak-hickory forests with islands of rocky bluestem prairie. It is an area that ranks only second to the Chautauqua Hills in abundance of hepatics but it breaks down into fewer groups when correlation of hepatics with other vegetation is made. The groups are:

Species found in upland oak-hickory forests on bark, soil, or dry rock ledges:

Porella platyphylloidea
Frullania brittoniae
Frullania eboracensis
Frullania inflata
Frullania riparia
Riccia beyrichiana
Riccia hirta

Species found on moist, north-facing, rocky, wooded hillsides occurring on bark, soil, and moist rock ledges:

Plagiochila asplenioides
Geocalyx graveolens
Lophocolea minor
Lophocolea heterophylla
Diplophyllum apiculatum
Scapania nemorosa
Porella platyphylloidea
Cololejeunea biddlecomiae
Frullania brittoniae
Frullania eboracensis
Frullania inflata
Frullania kunzei
Frullania riparia
Pellia epiphylla
Asterella tenella

Species found in the prairie islands are:

Anthoceros punctatus
Sphaerocarpus michelii
Sphaerocarpus texanus
Riccia beyrichiana
Riccia dictyospora
Riccia hirta
Riccia lamellosa
Riccia sorocarpa

The Osage area in general has comparatively few hepatics both in number of species and quantity of any species. The only exception is the genus *Frullania* which is to be found in any oak-hickory area. The dominant trees of this association are consistently *Quercus macrocarpa, Quercus muehlenbergii, Quercus velutina, Carya cordiformis* and *Carya ovata.* The oaks are by far the most abundant. On the bark of these trees *Frullania inflata* can always

be found and occasionally *F. eboracensis* and *F. riparia* will be observed. Moist, mossy, north-facing cliffs or banks in this association often have several species of hepatics, among which *Lophocolea heterophylla* and *Scapania nemorosa* are the most common. Often they are the only species present. If the moss *Leucobryum glaucum* is present on these banks a careful search of the area may reveal certain other forms. The following species, in addition to the two named above, may be found:

Jamesoniella autumnalis
Geocalyx graveolens
Lophocolea bidentata
Scapania undulata
Cephalozia bicuspidata

In a few places in the northern part of the Osage area there are places where the habitat is intermediate with that of the Chautauqua Hills. Such places have a larger hepatic flora but in general the characteristics of such sites are much more similar to types of the Chautauqua Hills and are thus considered with the latter area.

The prairie of the Osage area, if sandy, characteristically has a few species of which *Riccia beyrichiana, R. dictyospora, R. hirta, R. lamellosa* and *R. sorocarpa* are the only ones usually found. The rate of occurrence varies greatly.

The Flint Hills has such a small hepatic flora that no associations can be made. The only consistent correlation is the occurrence of *Frullania inflata* in all places where *Quercus macrocarpa* is found. This oak occurs along a few streams and bluffs.

The Dakota is primarily a prairie association on sandy soil, with numerous sandstone ledges, boulders, or flat surfacing sandstone exposures. Most of the hepatics in the area are found near the edge of the exposed sandstones. However, prairies dominated by *Andropogon gererdi* and *Andropogon scoparius* have an abundance of liverworts in some places. Species usually found are *Riccia beyrichiana, R. hirta, R. dictyospora, Asterella tenella, Mannia fragrans, Sphaerocarpus texanus* and more rarely *Anthoceros punctatus* and *Notothylas orbicularis.* On the bark of trees along streams or ravines will be found the ever present *Frullania inflata,* if *Quercus macrocarpa* is present.

All other areas of Kansas have so few hepatics that no correlation is possible. Those found in such areas usually are associated with springs or alluvial deposits on streams. The latter type stations are very unstable and thus allow for little in the way of comparisons.

Phytogeography

The hepatic flora of Kansas is a flora composed mainly of ubiquitous, widely distributed species which occur to the east, north, west and south of the state. This is, as might be expected, due to the location of the region in nearly the exact center of the United States. The environment is such that only those species with a wide degree of habitat toleration find it possible to survive.

The hepatic flora of the State is decidedly dominated by members of the Marchantiales whose species, though not more numerous, are much more abundant. They form the characteristic component of the State's hepatic vegetation and in many sites an observer finds only this group represented.

A few species seem to indicate that a relationship to the southern, southeastern and southwestern hepatic floras is evident.

These species are:

Frullania kunzei
Oxymitra paleacea
Plagiochasma rupestre
Plectocolea fossombronioides
Riccia campbelliana
Riccia dictyospora
Riccia trichorcarpa
Sphaerocarpus michelii

Frullania kunzei is listed by Frye and Clark (1937-1947) from North Carolina, Arkansas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, West Indies and South America. In Kansas it is found in the Ozark Plateau area in extreme southeastern Kansas. It thus is not far removed from Arkansas.

Oxymitra paleacea has been reported in Texas and Oklahoma and the writer has collected it in those two states and in six counties in Kansas. This species, then, is clearly southern in its affinities ranging into Mexico and South America. It also occurs in North Africa and Europe.

Plagiochasma rupestre is reported by Frye and Clark (1937-1947) as occurring in North America in New Mexico, Arizona and Mexico. However, there are specimens in the herbarium at the University of Kansas from Texas, Oklahoma and extreme western central Missouri. Our Kansas collection, therefore, completes the gap from Missouri to Mexico.

Plectocolea fossombronioides has a range according to Frye and Clark (1937-1947) of Connecticut, Ohio, Illinois, North Carolina, West Virginia and New Jersey. Thus Kansas seems far out of range for this species; however, Wittlake (personal communication) reports that he has specimens (verified by Evans) from Arkansas.

Kansas material (also verified by Evans) is, then, not far out of the known range of the species but nevertheless is an important extension of range.

Riccia campbelliana was reported by Frye and Clark (1937-1947) in California; by Jacobs (1951) in Georgia and Arkansas; by McAllister, Hoglund and Whitehouse (1932) in Texas; and it has been collected by the writer in Oklahoma and Kansas.

Riccia trichocarpa has been reported by Frye and Clark (1937-1947) from California, Oregon, Texas and Oklahoma in the United States. It occurs in several counties in Kansas and Schuster (1953) reports a single station in Minnesota. The species ranges into lower California and is definitely southern in its affinities.

Sphaerocarpus michelii is a species which has probably been overlooked or misinterpreted. Frye and Clark (1937-1947) report the species from Texas and Thompson (1948) reported it from Kansas. The writer has collected it in Arkansas, Oklahoma and several places in Kansas. Indications to date, therefore, are that the species is southern in its range.

Other species show some relationship to southern and southwestern floras. The two stations of *Porella pinnata* on dry limestone ledges, mentioned previously, is an example of the habitat of this species in the South. *Sphaerocarpus texanus* seems to be mainly southern in its range at least in abundance.

About the only indication of a relationship to northern hepatic floras is the occurrence of *Scapania irrigua* from a glaciated region in northeastern Kansas.

A few species might reveal relationship with other areas, particularly the south, if taxonomic and distributional details were known. In general much more field work needs to be done before many phytogeographic interpretations in the Hepaticae can be made.

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A Pollen Profile Study of the Muscotah Marsh [1]

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ABSTRACT: This paper treats of a pollen profile of a raised artesian marsh in Atchison County Kansas, samples being taken at 2-foot intervals.

The marsh can be divided into five distinct strata. *Abies* pollen was found at all levels from 36 feet to 12 feet, and is the only tree to appear in an unbroken succession of levels. Herbaceous plants replaced the woody plants in the marsh and immediate environs between the 22 and 20-feet levels. The vegetative successions were not clear cut until the herbaceous plants become dominant.

The successions were *Abies* to *Abies-Picea-Larix*, to all conifers, to Cyperaceae-Chenopodiaceae-Gramineae, to Cyperaceae-Gramineae, indicating a succession of weather conditions from wet-cool, to moist-warm to wet-cold to warm-dry.

The raised artesian marsh from which the material for this study was obtained is located at the east edge of the flood plain of The Delaware River, 1½ miles south of Muscotah in the NE¼ sec. 16, T. 6 S., R. 17 E., Atchison County, Kansas (Horr & McGregor 1948)[2]. Artesian water shows up in several places both north and south of this locality. At present this marsh covers about seven acres but there are definite indications that at earlier dates it covered a much greater area. It seems probable that the source of this water is a buried glacial till, as such a till has been tapped 6 miles east and ½ mile south of this locality at a level approximately 100 feet above that of this marsh. An artesian well at the edge of this marsh, which has been flowing for over 30 years, had enough pressure to raise the water 20 feet above the level of the ground when it was drilled and cased. It is evident that the pressure has been reduced considerably in the last few years, as is indicated by a reduction

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2. Horr, W. H. & R. L. McGregor, 1948. A Raised Marsh Near Muscotah, Kansas: Trans. Kan. Acad. Sci., Vol. 51, No. 2.

in the flow of water from both the well and the surface of the marsh, and also by the fact that from the fall of 1952 to the fall of 1953 the material in the marsh settled and became so compact that it was very difficult to take samples from the lower levels.

The material in this marsh has been laid down on a flood plain of stratified clay, sand and coarse gravel. The water supply has apparently been continuous since the start of this marsh but there are indications that the flow of water has varied considerably during the time of the development of this marsh. The surface vegetation is made up of typical marsh plants with the sedges being strongly dominant. (Horr & McGregor, *op. cit.*) During the drought of 1952-53 grazing cattle kept the sedges cropped off and the grasses and dicotyledonous plants increased greatly. R. L. McGregor, The University of Kansas, isolated pollen from this marsh in 1950.

METHODS

Samples were taken with a Davis punch-type sampler at intervals of 2 feet. Certain strata, composed of sand, clay and vegetation, were too hard to be handled with this sampler. A ¼-inch rib was attached to one side of the cylinder with which to expand the hole as the sampler was forced downward. This was effective until the fall of 1953 when the settling of the marsh, due to a reduction of water pressure, made it necessary to resort to levers to get through the harder strata.

The samples were examined for pollen, seeds, leaves, mollusk shells and other material which might help to give a more complete record of the fauna and flora of this area back through the ages as it was being recorded by nature. Numerous water pockets made it difficult to get a good series of samples at consecutive levels. The nature of the material obtained made it necessary to use a rather severe sodium hydroxide-acetic anhydride treatment to free the pollen for study. Neither alcohol nor detergents were effective on this material.

RESULTS

The profile in this marsh can be divided into five rather distinct strata, based on the physical make-up of the deposit:

1. From 1 to 10 feet the plant material, which is only partially decomposed, is very coarse.
2. From 10 to 22 feet the vegetation is much more decomposed and reduced to rather small fragments.

3. From 22 to 26 feet is a very dense stratum composed mostly of clay and a considerable amount of sand with about 8% of the total dry weight being organic. (Analysis made by The Kansas Geological Survey Service)
4. From 26 to 32 feet is plant material of extremely small sizes, mixed with some clay and sand.
5. From 32 to 36 feet is a mixture of clay and plant matter much like that found in 3 but with a much greater percentage of sand.

Marl and mollusk shells are common in the first 26 feet with their greatest concentrations where there is clay present.

In the first stratum various genera of Cyperaceae furnished from 86% to 90% of the total pollen identified at the various levels. The Gramineae furnished about 7% and about 5% were unidentified except to determine that they were mostly Compositae. Chenopodiaceae contributed 2% at 6 feet and *Populus* 4% at 8 feet.

In the second stratum Cyperaceae provided most of the pollen down to 18 feet, then dropped to 30% at 20 feet but did not appear at any lower level. Gramineae provided 9% of the pollen at 12 feet and dropped to 3% at 18 feet but was not found at any lower level. *Abies* furnished most of the tree pollen, starting with 3% at 12 feet and increasing to 70% at 22 feet. All of the other woody plants provided small amounts of pollen at various levels with all of them, except *Quercus,* showing at 22 feet.

In the third stratum *Abies* again provided most of the total pollen. All of the other woody plants except *Picea* and *Quercus* provided small quantities of pollen. Chenopodiaceae provided 11% at 26 feet and there was about the usual number of unknowns.

In the fourth stratum at 28 feet *Abies* pollen dropped sharply to 12% and increased to 21% at 30 feet. *Populus* showed the most pollen with 36% at 28 feet and 31% at 30 feet. All of the other woody plants contributed small amounts of pollen at 30 feet, and all except *Pinus, Tsuga* and *Picea,* appeared at 28 feet. Chenopodiaceae contributed 10% of the pollen at 28 feet with unknowns averaging about 10%.

In the fifth stratum the profile was again dominated by *Abies* pollen, with *Picea* and *Larix* the only genera to appear at all levels, and *Quercus* the only woody plant which did not appear. *Corylus* and *Tsuga* appeared only at 36 feet while *Pinus* provided 5% of the pollen at 34 feet and 2% at 36 feet. The only herbaceous pollen to appear in this stratum was Chenopodiaceae which contributed 5% at 32 feet, and the unknowns which averaged about 10%.

DISCUSSIONS

It seems obvious that these strata are the result of factors other than the vegetation, and that the climate was the most important factor. Strata 1 and nearly all of 2 are dominated by the remains of herbaceous plants but there is a rather sharp dividing line at about 12 feet. Above this level there has been enough water present to prevent the decay of the vegetation but below this level the vegetation has been reduced by decay to a brownish black mass of very small plant fragments. This indicates a more favorable oxygen supply such as would be the case if the vegetation was not submerged in water. The sharpness of the line separating these two strata rules out the possibility of its being due to the difference between the ages of these strata.

The silt which makes up 92% of the third stratum could have been brought in by flood waters from the Delaware River or by surface erosion of the higher ground to the south and east of this marsh. The absence of any appreciable amount of silt above this stratum might be explained by the upward growth of the marsh being rapid enough to keep it above the source of the silt. However, in view of the fact that the next lower stratum has only a small amount of silt, this does not seem like a very valid explanation.

As stated above, the fourth stratum contains very little silt and the plant material has been reduced to very small particles. At certain places conifer wood and leaves were encountered in large quantities. This wood is much better preserved than the other plant material found in this stratum.

The fifth stratum is much like the third, except that the decay of the plant material is more nearly complete and there is considerable wood present. It becomes quite evident that the absence of large quantities of silt in the fourth stratum is the only thing which separates the lower 14 feet into 3 strata.

The interpretation of the pollen profile in terms of climatic conditions is somewhat confused by the fact that we are dealing with relic vegetations. Vegetative changes in the surrounding area may have preceded the changes in the marsh by a great many years. This is well illustrated by the mollusk shells recovered at various depths. Dr. A. A. Leonard of The University of Kansas examined the shells and stated that some were pleistocene forms. He also stated that "snails now living there have not been found in the midwest in any other place south of the northern part of Iowa."

The pollen appearing most consistently in this study is *Abies*

which is now found at all levels up to 12 feet. This pollen indicates a rather definite series of climatic changes, especially when correlated with other pollens studied. With *Abies* furnishing 53% of the pollen at the beginning of the marsh it is apparent that the climate was cool and moist. The presence of the other conifers and the relative absence of deciduous trees at this level all indicate at least a moist climate and one that was much cooler than at present. The increase in *Abies* pollen to 67% at 34 feet followed by the decrease to 60% at 32 feet might not be too significant were it not for the drop to 21% at 30 feet. More significant than this is the abrupt increase in all of the other tree pollens at this level. Especially significant is the sudden increase in *Corylus, Populus* and *Quercus* pollen at the 30 and 28-foot levels. These are trees of warmer and drier climates. The further drop of *Abies* pollen to 12% at 28 feet, the disappearance of *Pinus, Picea* and *Tsuga* coupled with the increase of *Corylus* and *Populus* pollens indicate that there was a considerable increase in temperature, and probably a decrease in moisture. However, the decrease in *Quercus* pollen does not follow the expected pattern. The sudden increase in *Abies* pollen to 63% at 26 feet coupled with the reappearance of *Pinus, Tsuga* and *Larix* and the sudden drop in *Corylus* and *Populus* indicate that the climate had changed back to a more cool and moist period. This trend continued at the 24-foot level where the *Abies* pollen reached 85% and again reversed itself at the 22-foot level where all of the woody plants, except *Quercus,* were present. The most striking change came at 20 feet where the *Abies* pollen dropped to 20% and all other woody plants, except *Larix,* disappeared and the pollen picture became dominated by Cyperaceae and Chenopodiaceae, each of which furnished 30% of the total pollen. This definitely marks the transition from a forest to a grassland formation brought about by a continuing decrease in moisture and an increase in temperature. The continuance of *Abies* up to the 12-foot level probably can be explained by the continued presence of cold water coming up from below and maintaining these trees as a relic vegetation long after *Abies* had disappeared from the surrounding land areas. The influx of large amounts of Chenopodiaceae pollen, along with that of Cyperaceae at 20 feet, indicates competition between the herbaceous plants for dominance of this area as the trees disappeared and herbaceous plants took over. The Cyperaceae won the struggle because this is a much more favorable habitat for them. There are no species of Chenopodiaceae growing on the raised portion of this marsh at the present time.

After the grasses became established at 18 feet there seems to have been little change in their prevalence. Today there are more grasses and Compositae than were present in 1951, due to the destruction of the tall sedges and the decrease in surface water.

The relative absence of *Quercus* in the upper 20 feet poses an interesting question. One would assume that *Quercus* pollen would have been carried in from the surrounding area and, unless there was a very drastic change in the climate, there should have been a considerable number of these trees present. The distribution of *Pinus* pollen is quite different from that which is usually found; in fact, it is drastically different from that which Roland Anderson (University of Kansas) found in a similar situation 2½ miles to the south of this locality. There, *Pinus* furnished 100% of the pollen at the lowest level and continued upward in varying amounts for 15 feet where it contributed 39%. No determinations have yet been made above that level. It is altogether possible that the erratic appearance of *Pinus* pollen in small quantities can be attributed to the fact that there might not have been any pine trees growing at this marsh and that the *Pinus* pollen which is present was wind carried.

Because of the many papers written on pollen analysis of bogs and marshes, the author felt that a review of the literature would be superfluous in this paper. However, the author felt that this work was worth doing, because no other marsh in this region has yet yielded fossil pollen by which the post-Pleistocene flora and climate could be studied. Further attempts will be made to recover pollen from an artesian marsh in southwestern Kansas where all preliminary tests have been negative.

SUMMARY

1. This a study of pollen profile of a raised artesian marsh in Atchison County, Kansas, made from samples taken at 2-foot intervals.

2. The material in this marsh can be divided into five distinct strata.

3. *Abies* pollen is found at all levels from 36 feet to 12 feet and is the only tree to appear in an unbroken succession of levels.

4. Herbaceous plants replaced the woody plants in the marsh and the immediate environs between the 22 and 20-foot levels.

5. The vegetative successions were not clear cut until the herbaceous plants became dominant at the 20-foot level.

6. The successions were: *Abies,* to *Abies-Picea-Larix,* to all conifers, to Cyperaceae-Chenopodiaceae-Gramineae, to Cyperaceae-Gramineae.

7. The indicated weather conditions are: wet-cool, to moist-warm, to wet-cold, to warm-dry.

	Depth in feet	Abies	Pinus	Tsuga	Picea	Larix	Corylus	Populus	Quercus	Gramineae	Cyperaceae	Chenopodiaceae	Unknown
Very coarse, partly decayed vegetation	2									9	86		5
	4									7	90		3
	6									6	86	2	6
	8							4		5	86		5
	10									7	88		5
Decayed vegetation with small fragments	12	3								9	64	8	16
	14	5			1					5	63	12	14
	16	5	1							7	70	2	15
	18	10					10	4	1	3	60	2	10
	20	20				10					30	30	10
	22	70	1	6	2	2	2	7					10
Silt 8% veg.	24	85					2	8					5
	26	63	2	8		2		4				11	10
De-cayed veg.	28	12				2	21	36	5			10	8
	30	21	4	5	2	21	5	31	10				11
Silt and decayed veg.	32	60			15	5		5				5	10
	34	67	5		10	10							8
	36	53	2	12	9	12	1						11

Silt: Only Pinus pollen has been found below 36 feet.

TABLE 1.—Pollen profile of the Muscotah Marsh taken at 2-foot intervals. These percentages are based on 100 pollen grains from each level.

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The Anatomy and Modes of Preservation of the Genus *Cardiocarpus spinatus* Graham

By ELMER A. ROTH

ABSTRACT: Four modes of preservation of the fossil seed genus, *Cardiocarpus spinatus* Graham, are described as follows; petrifactions, nucellar coal balls, cuticular remains, and impressions. Details of morphology and anatomy as determined from the coal ball seeds and nucellar coal balls are illustrated and discussed. New information is presented about the sclerotesta, endotesta, and nucellus tissue. An elaboration is made of the structure of the sarcotesta and gametophyte. A new term "nucellar coal balls" is suggested for certain specimens preserved as free nucellar areas of the seeds. A review of theories relative to the lack of embryos in Paleozoic seeds is given. A brief discussion is made with respect to the preservation of nucellar coal balls in coal.

INTRODUCTION

Brongniart (1828) described the genus *Cardiocarpon* as "fruits compressed, lenticular, cordiform or reniform, terminated by a somewhat acute point." Since Brongniart's investigations, many others have contributed to the study, but his work has become the foundation for the study of fossil seeds as we know them today.

The purpose of this paper will, in essence, be twofold. First, to present a description of some new material which Dr. S. H. Mamay of the U. S. Geological Survey has called "miniature coal balls." I would like to enlarge on Dr. Mamay's proposed descriptive nomenclature and submit the term "nucellar coal balls" for these loose "casts" or "nutlet" appearing specimens (figure 4), because the preserved organic material appears as a miniature coal ball, and the preservation is of the nucellar region of the seed.

Secondly, to add to our current state of knowledge of the seed *Cardiocarpus spinatus* Graham based on additional well-preserved material found in coal balls from the coal fields of West Mineral, Kansas, and the Clay Products Company mine one mile southeast of What Cheer, Iowa.

HISTORY

Andrews and Felix (1952), in their excellent work on the gametophyte of *Cardiocarpus spinatus* Graham, present a brief history of the genus, however, some value may be gained by future workers if the history of the genus is enlarged upon in this paper.

Among those who investigated the genus *Cardiocarpon* (now referred to as *Cardiocarpus*) prior to 1900 are included Brongniart (1828, 1874, 1881) who established the genus and described a number of species, and Dawson (1865, 1896) who, while working with *C. cornutum*, arrived at the conclusion that the "fruits" described by Brongniart were in reality seeds, because of

> "2-cotyledons, a strong membranous or woody tegemen, surrounded by a fleshy outer coat with a notch at the apex which represented the foramen or micropyle of the ovule."

Hooker and Binney (1855), Lesquereux (1880), White (1899), and Williamson (1877) were concerned with the history, distribution, and descriptions of various species of *Cardiocarpon*, as well as other carboniferous seeds and seed-bearing plants. Lindley and Hutton (1833, 1837) investigated the paleozoic seeds of Great Britain, and described several species of *Cardiocarpon* found in that region. Newberry (1853, 1873) worked a great deal with compressions and impressions and has presented a general discussion and description of the genus. He also refers to and illustrates an impression of a cordaites stem bearing several, what he calls, "cardiocarpa." These "cardiocarpa" appear to be impressions of the nucellar area of a *Cardiocarpus*-type seed. Solms-Laubach (1891) presents a discussion of the affinities of paleozoic seeds and theories relative to their lack of embryos.

Many of the specimens found and described prior to 1900 were none too well preserved. In most instances specimens were found as compressions and/or, impressions with little or no cellular tissue preserved, making it quite difficult to present adequate descriptions. The lack of perfect specimens, and the relatively inefficient techniques did not, however, prevent these early investigators from producing work which has become the sound foundation for the investigations being carried on today.

Since 1900, many investigators have delved into the field of fossil seeds, some adding little to the knowledge previously presented, others making a definite contribution to our meager accumulation of information. Upon looking over the works of recent investigators we find that Andrews and Felix (1952) have produced an

excellent description of a well-preserved gametophyte in the species *Cardiocarpus spinatus* Graham; Arber (1906, 1914) has worked on a revision of seed impressions in British Coal Measures; Arnold (1938, 1947) presents an excellent discussion on paleozoic seeds; Chamberlain (1935), and Coulter and Chamberlain (1917a, 1917b) present a phylogeny and comparison of the Cordaitales with the cycads, *Ginkgo,* and other gymnosperms and also offer (1917b) a theory regarding the lack of embryos in paleozoic seeds. Graham (1935) describes the species *Cardiocarpus spinatus;* Oliver (1902, 1903) worked with the relationships of *Cardiocarpus* to seeds of the cycads and *Ginkgo;* Reed (1946) presents an excellent discussion as well as some illustrations of some seeds found at the coal mines near What Cheer, Iowa, and considers them to be comparable to *Cardiocarpus spinatus* Graham, and finally Scott (1909a, 1909b) and Seward (1917) list and describe various species in the genus and present some morphological descriptions.

Here again, as in early day investigations, the specimens of seeds, in general, were too poorly preserved to present adequate descriptions of the entire seed. The gametophyte, and the sclerotesta are the two zones of the seed that have received the most attention, and of these only the gametophyte, Andrews and Felix (1952), has been adequately discussed. Most investigators, Andrews and Felix (1952), Graham (1935), Reed (1946), admit that the lack of proper preservation has made complete descriptions of the seeds quite difficult. Even though poorly preserved seeds are the rule rather than the exception, the use of the parlodion peel method, the gelatin method, and improved microscopic instruments have resulted in more complete descriptions of all types of fossils than has heretofore been done.

TYPES OF PRESERVATION

The seeds, generally, are preserved in coal balls along with other organic material (fig. 8). It is through this type of preservation that cell and tissue structure is best preserved.

Nucellar, or miniature, coal balls occur directly in the coal. Many times these may be found lying loose in weathered areas of the coal fields, or where the "washings" from the coal are dumped. As shown in figures 4, 5, they are heart-shaped, platyspermic, resembling the description presented by Brongniart (1828). In diameter they vary from 8mm x 8mm to 15mm x 12mm with an average of 10.5mm x 8.5mm (figs. 3, 6, 7).

Another form of preservation may be found as impressions in shale. It is from this form of preservation that most of the early day investigations were done.

One other form to be considered is that of cuticle remains. This form usually does not show the true appearance of the seed, but has been found in close association with the cuticle of *Cordaianthus*, being quite abundant in the shale layer at Lone Star Lake, Kansas.

DEGREE OF PRESERVATION

The degree of preservation of organic matter in the nucellar coal balls varies a great deal. Of the 114 specimens collected at West Mineral, Kansas, 30 showed well-preserved gametophytic tissue (fig. 13). Of these, 14 specimens show the presence of structures resembling archegonia at the micropylar end. Forty-four were found to have been infiltrated with a varying amount of pyrite. Some were so heavily impregnated that the study of the tissue was an impossibility. In others, the penetration of pyrite was very slight, and, though sometimes making microscopic study somewhat difficult, did not completely obscure the tissue from view. Of the 44 nucellar coal balls found impregnated with pyrite, 3 were found to have the sclerotesta preserved as the outermost tissue. The remainder of the 114 specimens collected were found to be true casts with the organic material being completely replaced. Here, as in many specimens found embedded in coal balls, remnants of the megaspore membrane and of the nucellus may be distinguished as dark brown lines around the megaspore area.

The outermost part of these nucellar coal balls is, generally, the megaspore membrane, however, some specimens may have as the outer covering a portion of the nucellus tissue, endotesta, or sclerotesta. Evidence on hand indicates that the "nucellar coal balls" consist of the nucellus area of the type found in *Cardiocarpus*. Any one of the 114 specimens will fit into any vacated area of a nucellus in any of the coal balls in our collection (fig. 6). Since *Cardiocarpus spinatus* Graham is the sole species so far discovered in Kansas coal balls, there is little doubt that they represent the nucellus area of this species.

When preservation is in the form of impressions one seldom, if ever, finds organic tissue preserved. As a rule it seems apparent that the compression of the outer sarcotesta has given rise to the erroneous concept of a winged seed.

DESCRIPTION

In considering, specifically, *Cardiocarpus spinatus* Graham, I find that those investigating the species since Graham's original description, Andrews and Felix (1952) and Reed (1946), have added much to our meager knowledge. However, it is felt, and admitted by authors concerned, that most of the descriptions were given from relatively poorly preserved material. I have been fortunate in having available specimens with almost perfect preservation of the various tissues. It is because of this excellent, well preserved material that I am presenting an additional, more complete, description of the species than has heretofore been published.

Since the seeds are bilaterally symmetrical almost all sections exposed in coal ball cuttings are usually oblique. This makes it difficult to establish definitely the true orientation of the seed, and, when the gametophytic tissue is found, it is difficult to determine the numbers, true position, and structure of archegonia (when present), and finally to establish definitely true cellular structure of the tissues exposed. I have been fortunate in that I have been able to obtain almost perfectly preserved specimens removed intact from coal balls, and therefore able to determine the exact plane of the sections made.

Graham (1935) notes that the sarcotesta of his specimen is almost completely destroyed, so he does not present a description of this tissue. Reed (1946) presents a general description, and illustrates, by camera lucida drawings, some of the tissues involved. Andrews and Felix (1952) present a somewhat clearer description, but note that in most specimens only the sclerotesta is preserved with the sarcotesta being seldom preserved intact.

In light of the statements concerning the lack, in most cases, of the preservation of the sarcotesta, it is of interest to note that in a number of seeds on file in the paleobotanical collection at the University of Kansas the sarcotesta and the epidermal layer are well preserved (figs. 2, 9, and 10). In general, these seeds show well-preserved tissues at all layers in the seed.

Epidermis: The epidermis is one cell thick. The cells are thin-walled, rectangular, averaging 70μ x 49μ in diameter. No stomata have been observed although occasionally there are found, at irregular intervals, structures in the epidermis that are suggestive of sunken stoma. Surrounding the cavities in these areas are small, parenchymatous, isodiametric cells, distinct from the normal cells found in the outer sarcotesta. Little can be said about the true

nature of these areas, but future specimens should be carefully scrutinized for further information and enlightenment as to their anatomical nature. (figs. 9, 10, and 11).

Outer sarcotesta: This tissue is generally 15 to 20 cells thick. There may be a greater or lesser amount in some specimens, dependent upon the development of the spines of the sclerotesta. Andrews and Felix (1952) state the cells to be about 165μ in diameter. The cells of our specimens average 168μ which is a favorable comparison. The cells are more or less isodiametric, parenchymatous, and closely packed (fig. 11). The tissue, as preserved in the coal balls, has a characteristic amber color with occasional cells being filled with a resinouslike substance having a somewhat darker brown color than the cell walls (fig. 8).

Inner sarcotesta: The cells of this tissue differ from those of the outer sarcotesta only in that they are about one-third the size of the outer sarcotesta. The cell walls are amber colored, and the lumen area of each cell is generally empty. The tissue, for the most part, varies from 40 to 50 cells thick, again dependent upon the development of the sclerotesta (fig. 11). Andrews and Felix (1952) state these cells to average 55μ in diameter. The cells of our specimens average 42μ x 42μ in diameter which is a favorable comparison.

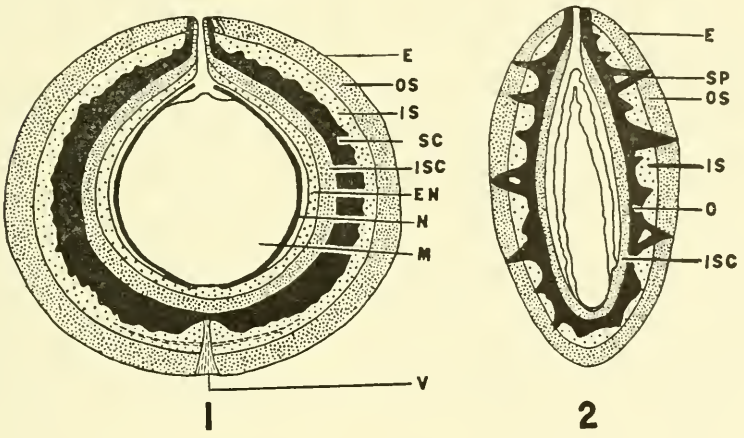
Sclerotesta: Graham (1935) describes the sclerotesta as being made up of two layers; an outer layer of thick-walled more or less isodiametric cells. He states this layer to be of variable thickness with spines at the outer surface. The second layer he designates as the inner layer, and this layer is made up of moderately thick-walled cells, elongated in the direction of the axis of the seed. Reed (1946) notes that the sclerotesta is exceedingly thick-walled, roughly isodiametric cells, and has a formation of spines. She does not mention the sclerotesta as being made up of two layers. Andrews and Felix (1952) note that the sclerotesta is the conspicuous portion of the integument, and that it is characterized by its spiny outgrowths.

A number of specimens in our collection are well enough preserved to show some hitherto undescribed features of this tissue. Due to the fact that most seeds, when exposed by cutting a coal ball, are found to be cut at right angles to the broad plane (text, fig. 2), the true significance and structure of this tissue has been difficult to ascertain. It was indeed fortunate, and an extreme piece of luck that Dr. Baxter, while working with a coal ball from the coal fields of West Mineral, Kansas, exposed an intact seed in such

a manner that it was possible to orient properly the seed with reference to its broad plane, and to begin making peels, at the very outset, on the broad plane.

A total of 44 peels were made, making it possible to determine the true location of the spiny projections of the sclerotesta. This was further corroborated by making 3-dimensional peels of other seeds in the collection.

It is quite evident in virtually every specimen that, as Graham indicated, the sclerotesta is made up of two distinct tissues—an outer and an inner. It is also quite evident that the inner tissue is, in turn, made up of two distinct zones.



Cardiocarpus spinatus Graham

FIG. 1—Diagrammatic longitudinal view of the broad plane.
FIG. 2—Diagrammatic longitudinal view of the narrow plane. E—Epidermis, OS—outer sarcotesta, IS—inner sarcotesta, OSC—outer sclerotesta, ISC—inner sclerotesta, EN—endotesta, N—nucellus, M—megaspore, V—vascular bundle, SP—spine of outer sclerotesta (note chamber).

Outer sclerotesta: It was found by the author that when observing this region of the testa, one must use caution in interpreting the general structure and geometry of the cells. Both Graham (1935), and Reed (1946) indicate that the cells in this tissue are roughly isodiametric, however, I have found the cells to be vertically elongated in the direction of the vertical axis of the seed, being seven to eight times longer than broad. The cells are extremely closely packed, sinuous, and almost hyphaelike in appearance. The cell walls are very thick, and the lumen area small. In a vertical cut at right angles to the broad plane, the cells in the spines tend to

become horizontally elongated, while a transverse cut of the seed shows the cells as isodiametric. The fact that a high percentage of seeds exposed in coal balls show a transverse, or oblique-transverse plane probably explains the usual concept of "isodiametric" cells.

The development of the spines in *Cardiocarpus spinatus* Graham is variable with the maturity of the seed. These projections may be slight in a relatively immature seed, projecting only into the inner sarcotesta. However, in the more mature seeds, the spines have been observed to extend to, and to abut on, the epidermal layer (text fig. 2, and fig. 1). It is believed that these variations in the development of the spines represent, as indicated previously, the maturity of a given seed, and should not be construed as having taxonomic value.

Also of import is the location of the spines on the sclerotesta. As indicated earlier, dependent upon the cut of the seed, one sees different aspects in the projection of the spines. In a cut at right angles to the broad plane, the spines are seen to project into the sarcotesta as far out as the epidermal layer, (text fig. 2, and fig. 1). However, in peels taken from the broad plane it may be noted that as a true median section is approached the projection of the spines lessen until they appear to be little more than a serration of the sclerotesta, (text fig. 1, and fig. 2). This constant variation in the development of the spines has been further verified by the use of 3-dimensional peels.

Another characteristic noted is that the outer sclerotesta is chambered as well as spined. This is evidenced by the presence of "islands" of parenchymatous tissue of the sarcotesta surrounded by the extensions of the sclerotesta (figs. 9 and 11).

The coloration of the outer sclerotesta is distinctive in being a very dark brown, the intensity due, undoubtedly, to the extremely thick-walled cells.

Inner sclerotesta: While the sclerotesta is made up of two distinct tissues, the inner sclerotesta has itself been found to be further divided into two distinct zones. These will be referred to as the outer zone of the inner sclerotesta, which is the zone abutting the outer sclerotesta, and the inner zone of the inner sclerotesta which is the inner layer of cells abutting the endotesta.

The outer zone of the inner sclerotesta: The tissue in this zone averages 20 to 25 cells in thickness. The cells are sinuous, vertically elongated, presenting a nearly isodiametric appearance in transverse, or oblique-transverse, sections, and appearing as sinuous

tubes in longitudinal section. They are relatively thick-walled near their juncture with the outer sclerotesta, but tend to become less thick-walled as they approach the inner zone. The cells have a distinct amber color and appear to be filled with a tan, resinouslike substance.

The inner zone of the inner sclerotesta: This zone is immediately adjacent to the endotesta. The zone appears to be six to eight cells thick, but may have been slightly thicker in the living state. This is evidenced by broken cell walls near the region of the endotesta. The tissue is distinguished from the rest of the inner sclerotesta by the thicker cell walls, and the fact that the lumen of the cells is consistently empty.

Endotesta: Graham (1935) makes no reference to any layer between the inner sclerotesta and the nucellus area in his descriptions of the seed. Reed (1946) mentions an inner fleshy layer lying between the sclerotesta and the nucellar area. However, her indication of this inner fleshy layer in her figure 2 is apparently only the inner sclerotesta. Andrews and Felix (1952) note the presence of an endotesta but state that the cellular tissue is poorly preserved, and make no attempt to describe it.

This tissue in our specimens is, in general, not too well preserved. However, in coal balls M-34, and 782-B, we have found some of the endotesta preserved so as to present some idea as to the depth of the tissue as well as cell shape and structure. The tissue appears to be 15 to 20 cells in thickness. This undoubtedly was variable, dependent upon the maturity of the seed. In transverse, or oblique-transverse, sections the cells are shown as isodiametric in appearance. In a longitudinal view the cells appear thin-walled, parenchymatous, rectangular to rhomboidal, varying from 56μ x 28μ to 154μ x 84μ with an average of 112μ x 42μ. Delimiting the tissue on its inner surface is a single layer of thicker-walled cells which served, probably, as an epithelial lining (fig. 14).

The cells are a rich amber color, and the lumen area is filled with a light brown resinouslike substance. This is a strikingly different tissue than that found in any other region of the testa making it quite easy to identify when preserved.

Nucellus: Graham (1935) notes that this tissue is poorly preserved, and does not attempt a description of it. Reed (1946) presents a limited discussion of this area, and Andrews and Felix (1952) mention the presence of this tissue but offer no discussion.

Here, as in the endotesta, the amount of tissue preserved is limited, but occasional seeds have provided material good enough to

give us an idea of its anatomical structure. In observing a mature nucellus, the author has found the cells to be moderately thick walled, closely packed, and with a coloration not unlike that of the endotesta. The cells vary in diameter from 28μ x 28μ to 56μ x 28μ with an average of 38μ x 28μ (figs. 14 and 15). As illustrated in fig. 15, the tissue is remarkable in apparently showing the presence of nuclei.

Megaspore membrane: Graham (1935) and Andrews and Felix (1952) mention the presence of this membrane, but offer little discussion as to its composition. Reed (1946) states that it is thick and conspicuous, and that

". . . in many seeds it appears firm and round and apparently outlines faithfully the shape and extent of the female gametophyte or endosperm . . ."

Little can be added to the information heretofore presented. Its identification in our specimens appears as a brownish colored membrane lying internally to the nucellus and abutting the external layer of cells of the gametophyte.

Gametophyte: Graham (1935) notes that there is no gametophytic tissue preserved in any of his specimens. Reed (1946) states that little of this tissue is present in her specimens, and therefore offers no discussion of it. With reference to her specimens, she indicates that

". . . there are occasional instances of tissue which may be endosperm, but most of the tissue within the membrane is obviously intruded material . . ."

Andrews and Felix (1952) were directly concerned with the gametophyte of *C. spinatus* Graham, and their excellent description has left little to be added. Due to the fact we have on file a number of nucellar coal balls with well-preserved gametophytic tissue (fig. 13), a little elaboration, but mostly corroboration, will be given here with reference to the work done by Andrews and Felix.

In general, our specimens agree with the dimensions Andrews and Felix give for their seed, (fig. 12). With reference to cellular detail of the gametophyte, we would like to add that the cells are delicate, parenchymatous, rectangular to isodiametric, varying from 70μ x 56μ to 126μ x 84μ with an average of 84μ x 84μ. The archegonia present in our specimens agree in size with that of Andrews and Felix. The archegonia in their specimen attained a maximum diameter of 0.5mm, and ours varies between 0.5 and 0.6mm. In no specimen could be found more than two archegonia, and these were at the

apex of the megaspore, equidistant on either side of the pollen chamber.

Vascular system: The vascular system seems to be adequately covered by Seward (1917), Coulter and Chamberlain (1917a), Graham (1935), Scott (1909a), Oliver (1902), and others, and needs little further discussion here other than to present a short summary of the works of one of the investigators. For this purpose, the work of Oliver (1902) will be considered, because he was more concerned with the genus as a whole and not with a particular species. He states that

". . . as the supply bundle enters at the chalaza and traverses the sarcotesta, it gives off a pair of bundles which run along the inner limit of that layer to the micropyle. The plane in which these two bundles run is the plane of flattening, generally designated the principal plane of the seed. The main bundle continues to the base of the nucellus, where it expands into the tracheal plate. From the margins of this plate a number of nucellar strands pass off peripherally in the wall of the nucellus and extends a variable distance in the direction of the pollen chamber . . ."

In this same publication, Oliver illustrates various genera of the paleozoic seeds with their vascular systems.

The best indication of the vascular system in any of my specimens may be seen in figure 2, which is a peel of seed M-6, and indicates the entrance of the main vascular bundle at the chalaza, and clearly shows the traversing strand in the sarcotesta.

SYSTEMATIC PROBLEMS

Due to the confusion that exists in the classification of paleozoic seeds, there is a definite need for a reconsideration of the various genera and species. It is important, where possible, to combine seeds having essentially the same internal characteristics as conforms to size, shape, and integumentation in order to eliminate superfluous generic names. Seward (1917) in considering this state of confusion, notes that

". . . the bionomics of paleozoic plants is a subject worthy of more serious attention than it has so far received . . ."

He indicates that the search for morphological characters would, in addition to other things,

". . . not only extend our knowledge of the morphology of ancient types, but would stimulate comparative study, and, incidentally, relieve the dullness of pure description . . ."

He specifically notes, with reference to systematic problems, that,

". . . one of the difficulties inseparable from the study of fossil plants,

namely the identification of impressions and casts with specimens exhibiting anatomical characters, is particularly well illustrated by seeds. The description of a genus based on mere external forms may sometimes be extended without great risk of error to include species found on anatomical characters, but on the other hand, there are many instances in which—despite a general resemblance in form and size between petrifactions and impressions—lack of evidence of generic identity requires the employment of distinctive names . . ."

There are many examples one could present to show superfluous names, and few investigators interested in this work are not familiar with most of them. In the consideration of *Cordaites* seeds, one is faced with the problem of certain descriptions indicating that some of them possessed wings. Arnold (1947) indicates that in general those flattened seeds with a narrow winglike border belong to the Cordaiteae. He further states that the seeds of the Cardiocarpales are flattened, heart-shaped seeds with the nucellar region being surrounded by an integument of which the outer layer is "laterally expanded into an encircling wing." He specifically states that

". . . It should be noted that in the Cordaiteae both the seeds and the pollen grains are winged, a fact that stresses the important role of wind in the life cycle of the plant . . ."

The evidence for a winged *Cardiocarpus* is based on those specimens preserved as compressions. It is primarily through this type of preservation upon which the concept that those seeds of *Cardiocarpus* are flattened and heartshaped, is based. Numerous intact specimens found in coal balls from West Mineral, Kansas, and the coal mines near What Cheer, Iowa, compels me to state that both concepts are erroneous, and I feel that there is no valid evidence of a wing being present on seeds of this group, nor are any members of the group flattened and heartshaped in external appearance.

The outline of a wing, as indicated by those specimens preserved in compressions, is quite obviously due to the compression of the sarcotesta. The evidence for the seeds being flattened and heartshaped has arisen from investigators seeing the exposed nucellar area, which is flattened and heartshaped. However, seeds, taken intact from the coal, and from coal balls, indicate that none possessed wings, and that they are more spherical than flattened in external appearance, and not heartshaped. Any specimen found to be definitely winged should be placed in the genus *Samaropsis* providing other characters conform to those attributed to that genus.

Identifying characters: One of the greatest needs in the study of fossil seeds is a need for a classification plan that would follow natural relationships rather than purely artificial characters. Just what should be considered in developing such a key is difficult to ascertain. In a classification plan for modern seeds Martin (1946) states that external characters are many and often varied among species of living seeds. Accordingly, Martin chose the embryo as the principal criterion in his classification, stating;

". . . the significant types of internal arrangement incline to be relatively few and comparatively stable. . ."

In considering a classification plan for paleozoic seeds, the complete lack of embryos renders impossible their use as a criterion for classification. Therefore, other more prominent and identifiable characters must be considered. The shape of the seed, platyspermic or radiospermic, has been used with some success in this way, Scott (1909a) and Seward (1917). I also find that the testa seems to be well adapted for use as an identifiable character. Here the numbers of layers of tissues, their thickness, cellular size and shape, distinctive formation, *i.e.*, sclerotesta spiny or not spiny, certainly have a distinct importance. The arrangement of the vascular system, when identifiable, and the external appearance of the seed, where possible, are other characters which may be used.

DISCUSSION

Theories on the lack of embryos in paleozoic seeds.

Solms-Laubach (1891) gives as a probable explanation of the lack of embryos in paleozoic seeds that,

". . . in these forms the development of the embryo proceeds slowly, as is the case at the present day with *Ceratozamia, Ginkgo,* and *Gnetum.* . ."

Accordingly, petrifaction may have usually preceded embryo formation.

Scott (1909a) notes the absence of embryos as being a,

". . . common character to all known paleozoic seeds, though in many the archegonia are preserved. . ."

He continues with,

". . . yet the seeds, as a rule, are evidently mature and not mere ovules. Neither, considering the frequent presence of pollen grains in the pollen chamber, can we assume that all the seeds found happen to be barren. It is possible that, though pollinated, they were not yet fertilized, the latter process taking place an appreciable time after the seed was shed; or again, it may be that a resting stage followed immediately on fertilization before any marked develop-

ment of the embryo had taken place. In any case it appears that in these ancient seeds the period of rest came much earlier with reference to the growth of the embryo than in most of our recent seeds. We find a relic of the old conditions in living cycads, in which the embryo is often scarcely to be recognized when the seed is ripe and ready for sowing. . ."

The most complete hypothesis with reference to the lack of an embryo in paleozoic seeds, is presented by Coulter and Chamberlain (1917b). It is known that embryos can be preserved in petrifactions, as witnessed by their abundant occurrence in the seeds of the Mesozoic Bennettitales. Coulter and Chamberlain do not agree with Oliver's (1902) suggestion that perhaps the long intraseminal period of the embryo seed plants had not been developed in the paleozoic. On the contrary, they believe

". . . the abundant endosperm invested by an efficient testa seems to be against this view . . . while . . . it should be remembered that the proembryo of the more primitive gymnosperms is quite extensive, and that even were it preserved it would hardly be recognized as an embryo. . ."

In the same discussion they postulate,

". . . that paleozoic seeds matured (developing testa) before fertilization, became detached after pollination, and subsequently developed a proembryo which did not invade the endosperm before germination, or invaded it in a very feeble way as compared with the extensive invasion in modern gymnosperms. . .," and that, ". . . checking the growth of the embyro if it is related to the organization of a testa, may occur at any stage; and if the testa is formed before fertilization (as may have been true in paleozoic seeds), the growth of the embryo may well have been checked at some stage of the proembryo. That even a well-organized testa does not check the growth of the embryo, however, is evidenced by the fact that even among existing gymnosperms, as cycads, the true embryo (as distinct from an extensive proembryo) may escape from the seed as soon as it is developed and grow as continuously as do the embryos of pteridophytes. In such a case, however, the chance of finding preserved a recognizable embryo invested by the testa would be as exceptional as of finding any very brief stage in the life history. It would seem, therefore, that in paleozoic seeds there was either no resting period between intraseminal and extraseminal development of the very young plant, or it occurred in the proembryonic stages. . ."

Scott (1909b) has suggested as probable

". . . that the nursing of the embryo had not yet come to be one of the functions of the seed, and that the whole embryonic development was relegated to the germination stage. . ."

Coulter and Chamberlain also note that

". . . since belief in the absence of embryos from paleozoic seeds rests as yet upon negative evidence, it should not be forgotten that the sections of suitably preserved seeds are far too few in number to overcome the uncer-

tainty of negative evidence or the possibility of abortive seeds. In fact, comparatively few seeds have been found attached to the shoots that bore them, and seeds that have fallen off at the immature stages suggested by all published figures of sections would be abortive seeds, so far as experience with the living plants is concerned. Only good seeds remain on the plant, and there is no record of a section of an attached paleozoic seed. Moreover, if the seeds germinated at once, as do those of the cycads, no embryos would be found except in attached seeds. The seeds of Bennettitales that show conspicuous embryos are all attached seeds, and it is altogether probable that such seeds of Cycadofilicales and Cordaitales will also show embryos . . ."

There have been little or no improvements of late on the foregoing postulations for we today have yet to find an embryo or even an attached paleozoic seed showing preserved internal structure. With the small bits of information available with reference to these paleozoic seeds, Coulter and Chamberlain's theory appears to be well founded, but it must remain only a theory until such time as the paleobotanical record either proves or disproves it. It does allow, however, a good working hypothesis to carry on research in this field for the time being.

Comparison of *Cardiocarpus* with *Ginkgo* and the Cycads

To attempt to place *Cardiocarpus* in its proper taxonomic niche of the family tree of plants is no easy task. Even with the knowledge at hand, no definite placement can be made until such time when embryonic development can be determined and definite attachment to the parent plant can be established. However, a comparison with some modern seeds can be made to show similarities in development and probable phylogenetic relationships.

To begin with, the nucellar attachment may be compared. We find in the modern day cycads and *Ginkgo* that only the upper portion of the nucellus is free, whereas in *Cardiocarpus* the only attachment of the nucellus is found to be at the chalaza. There is a distinct similarity in the development of the integument in all three groups of seeds in that there is an inner fleshy layer (endotesta), a middle stony layer (sclerotesta), and an outer fleshy layer (sarcotesta). In comparing the vascular system of the three groups it may be seen that the vascular system of *Cardiocarpus* is somewhat more complex than that of the living cycads and *Ginkgo*. It is interesting to note that the entrance of two vascular strands into the ovule and testa, is similar in the three groups. These are well illustrated and compared by Oliver (1902), and by slight modifications of the vascular strand of *Cardiocarpus* the trend towards

the development of the system in the cycads and *Ginkgo* may be seen.

Further comparisons between the cycads, *Ginkgo*, and *Cardiocarpus* include the prominent nucellus with a relatively large pollen chamber surmounted by a beak or "tent pole", all being quite similar in the three groups, though the pollen chamber of *Cardiocarpus* is the larger. With reference to the nucellar area we find that in all three groups the nucellus is platyspermic and "heart-shaped" following very closely the description Brongniart (1828) gave for the genus *Cardiocarpon*.

Additional comparisons we can make, are, for the moment, hypothetical, because of the lack of sufficient knowledge of paleozoic seeds. However, a free nuclear period following fertilization is a character probably shared by the three groups. The presence of swimming sperms known for the cycads and *Ginkgo* probably was a character present in the seeds of the Cordaitales. With reference to integumental development, Seward (1917) states,

". . . in both extinct and modern seeds the balance of evidence would seem to be in favour of attributing a single rather than a double origin to the integument . . ."

Coulter and Chamberlain (1917a) in comparing the majority of known paleozoic seeds with those of angiosperms, state,

". . . it is evident that the seeds (of the angiosperms) have advanced in the reception of pollen by the micropyle, and in the nutrition of the embryo; but that the general structure of paleozoic seeds is much more complex, with their elaborate vascular system, pollen chamber, and often highly differentiated testa . . ."

These comparisons are not made to indicate a direct lineage of development of modern gymnospermous seeds from the paleozoic seeds, but are here recorded to show similarities and possible heritage. This line of thought has been held for a number of years by prominent paleobotanists and no recent investigator has postulated a better comparison. Until such time as future discoveries provide the answers to the innumerable questions prevailing in the paleobotanical records, concepts as to development and phylogenetic relationships of present day plants with those of primeval forms must remain purely theoretical.

Theory of the preservation of Nucellar Coal Balls in Coal.

The preservation of the nucellar area of *Cardiocarpus* seeds in coal, as shown in figures 4, and 5, in addition to the finding of numerous similar specimens lying in the weathered areas of

coal fields (fig. 3), raises the question as to why the nucellar region was preserved and not the testa. It seems logical that the hardiest cells or tissues would be preserved while the more delicate cells or tissues would disintegrate.

It is known that since tissues rapidly decay in air, only those plants living in or near water have much chance of preservation as fossils. The exceptional facilities available for plant preservation during the Upper Carboniferous period is a probable explanation for the numerous fossil plants found in the Coal Measures. Arnold (1947) indicates that,

". . . the chief factors governing the extent of tissue preservation in fossil plants are (1) the kinds of tissues composing the plants, and (2) the conditions to which they were subjected preceding and during fossilization . . ."

He further states that,

". . . the disintegration of plant tissues proceeds according to a rather definite selective order of decomposition. First to disappear are the protoplasmic contents of the cells . . . Those tissues consisting of thin-walled cells usually disappear next. These are followed in order by wood and bast fiber cells, suberized cork cells, and cutinized spores and epidermal fragments . . ."

The foregoing being true, why were nucellar coal balls preserved in coal minus their integument? Again we go to Arnold (1947) to find a partial answer. He indicates that the escape from serious damage of cells by crushing may be caused by a previous infiltration of mineral matter into the cell cavities, and where cell cavities have become completely filled, the structure may suffer little or none at all. The explanation as to why thin-walled cells are not crushed when the wood cells are, is that the thin walls are more permeable to mineral matter in solution. Arnold states that,

". . . the effect of mineral infiltration is to add strength to the tissues, whereas in the less permeable thicker-walled cells the cavities remain empty, rendering them more susceptible to collapse . . ."

Here, then may lie the nucleus of a final answer to the problem. Undoubtedly mineral infiltration into the nucellar region of the seeds (through the micropyle opening) was quite rapid to preserve the tissue as we find it in the nucellar coal balls. Some infiltration may have occurred simultaneously in the sarcotesta, but to a lesser degree, or the sarcotesta resisted infiltration because of the presence of the cuticle layer externally to the epidermal layer. The cells of the sclerotesta, on the other hand, being sclerotic in nature,

resisted infiltration of any mineral matter. During the coal forming process, the noninfiltrated integuments of the seed were compressed and carbonized while the infiltrated nucellar areas were preserved as miniature coal balls.

SUMMARY

The anatomy and modes of preservation of the genus *Cardiocarpus* have been studied, with special attention to the anatomy of *Cardiocarpus spinatus* Graham.

Special attention has been given to the sclerotesta of the seed. This portion of the integument is made up of two distinct tissues: the outer sclerotesta is chambered and spined, the spines often extending to the epidermis in sections taken through the narrow plane with little or no extension of the spines in sections parallel to the broad plane, while the inner sclerotesta is made up of two distinct zones.

Additional information has been given on the tissues of the sarcotesta; an account has been given of the endotesta and the nucellar tissue that these tissues are quite distinct from other tissues of the seed.

A new mode of preservation has been described and illustrated. The specimens concerned in this new mode of preservation have been designated as "nucellar coal balls."

A review of the theories relative to the lack of embryos in paleozoic seeds is given, and a theory has been postulated with respect to the preservation of nucellar coal balls in coal.

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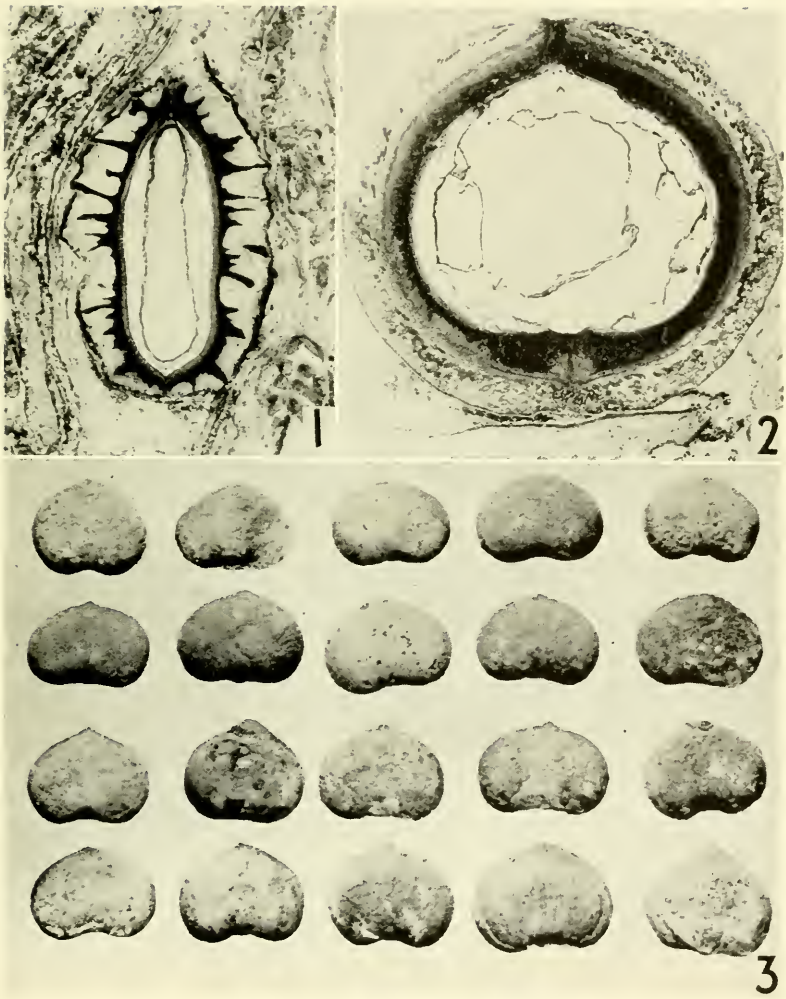

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FIG. 1. Transverse-oblique section through the narrow plane showing the spines of the sclerotesta extending to, and abutting on, the epidermis. × 5¾.

FIG. 2. Median-longitudinal section through the broad plane. Micropyle opening is visible at top center. At bottom center are shown vascular strands entering the sclerotesta, and branching into the inner sarcotesta. × 5½.

FIG. 3. Nucellar coal balls as found at West Mineral, Kansas. All consist of just the nucellar region except for the specimen second from right in bottom row which shows some attached sclerotesta. × 2½.

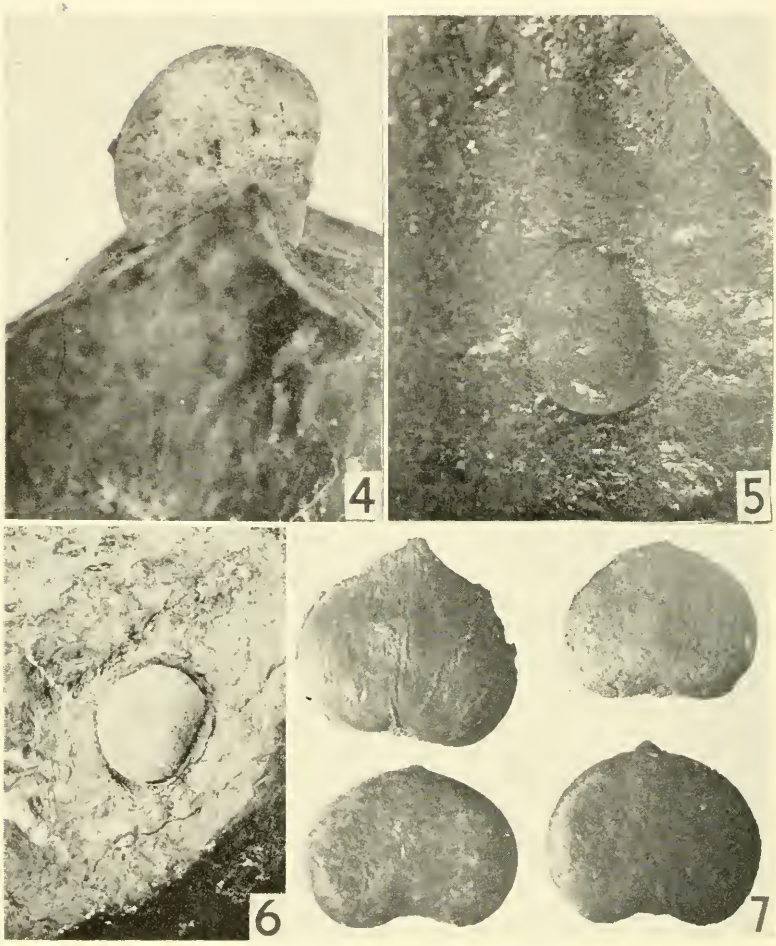

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FIG. 4. Nucellar coal ball embedded in coal. × 5½. Courtesy—Dr. S. H. Mamay, U. S. Geological Survey.

FIG. 5. Nucellar coal ball embedded in coal collected from West Mineral, Kansas. × 3½.

FIG. 6. Nucellar coal ball from West Mineral, Kansas, showing its exact fit into a vacated nucellar area of *Cardiocarpus spinatus* Graham in a coal ball from the What Cheer Mine, Iowa. × 2½.

FIG. 7. Enlargement of nucellar coal balls from West Mineral, Kansas. Specimen in upper left hand corner has retained the sclerotesta as its outermost covering. × 5½.

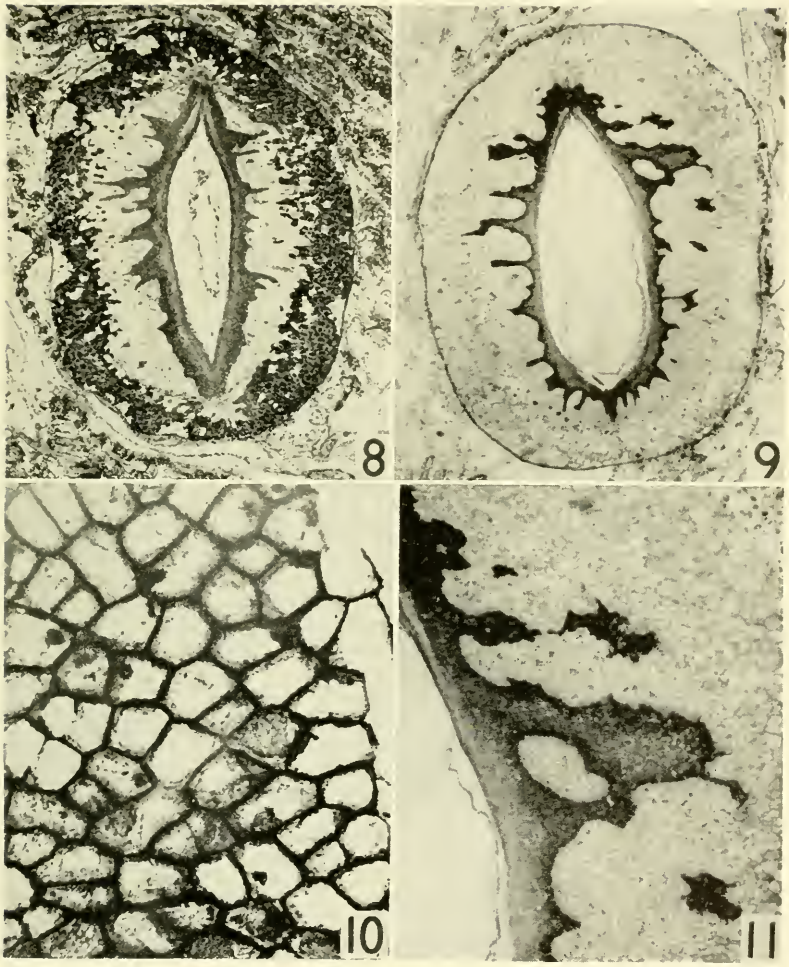

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FIG. 8. Oblique-transverse section photographed from etched surface of coal ball. Tissues from outside towards center are: Outer sarcotesta (black cell contents), Inner sarcotesta (cells smaller and empty), spiny sclerotesta, fibrous inner sclerotesta, endotesta, and nucellus. × 7.

FIG. 9. Oblique-transverse view showing well preserved tissues of the testa. Note chamber in the outer sclerotesta in the upper right hand corner of illustration. × 6½.

FIG. 10. Photomicrograph of epidermal cells. × 20.

FIG. 11. Enlargement of a portion of fig. 9 showing, from right to left: The large cells of the outer sarcotesta, the smaller cells of the inner sarcotesta, chambered outer sclerotesta, and inner sclerotesta. × 10.

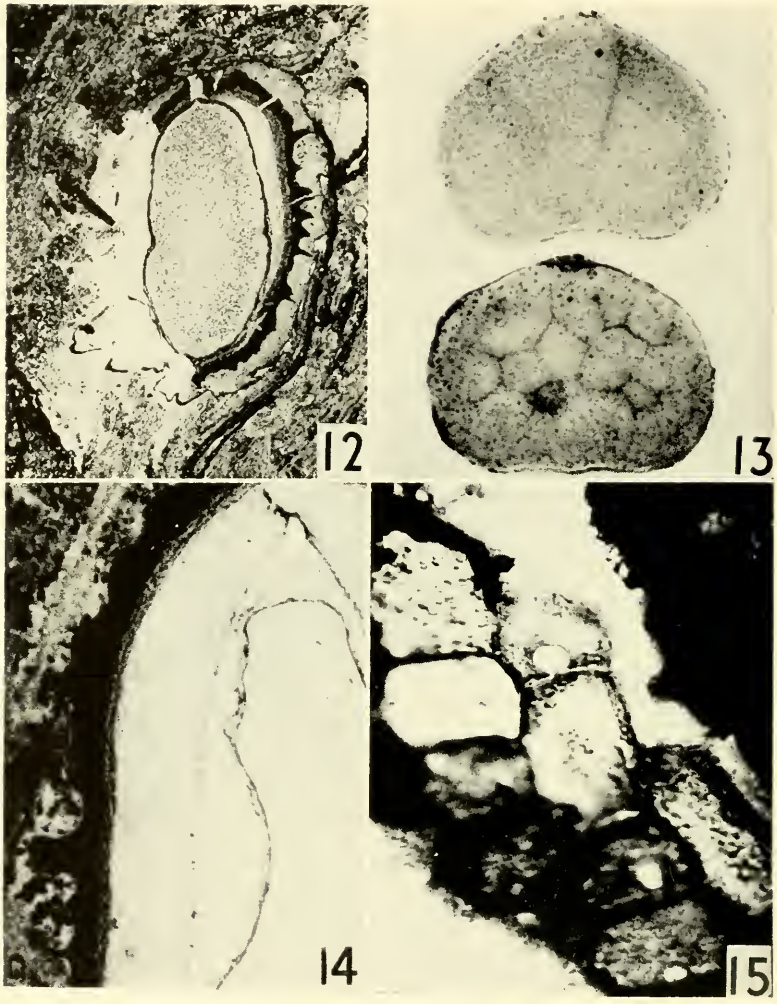

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Fig. 12. Oblique-transverse section through narrow diameter of a seed containing a gametophyte. × 6½.

Fig. 13. Peels of gametophytic tissue from nucellar coal balls. An archegonium may be seen immediately left of the micropylar region in upper peel. Pentagonal pattern of bottom peel appears to be due to mineralization. × 6.

Fig. 14. Oblique-transverse section through narrow diameter showing extent of endotesta and its epithelial lining. From left to right the tissues are: Outer aclerotesta (large black band), inner sclerotesta (lighter wavy portion immediately internal to the outer sclerotesta), Endotesta (wide band of cells light in color), Epithelial lining (dark band, one-cell thick, on inner surface of endotesta), Nucellus tissue, Megaspore membrane. × 20.

Fig. 15. Photomicrograph of nucellus tissue. Note the appearance of nuclei in some of the cells of the tissue. × 40.

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The Distribution and Subspeciation of *Erebia epipsodea* Butler (Lepidoptera: Satyridae)*

BY

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INTRODUCTION

This is the second in a series of papers on the subspeciation and distribution of the species of *Erebia* found in North America. The purpose of these papers, and those to follow, is to summarize on the specific level our knowledge of the genus in the Nearctic region. The author's intention is to provide for future workers on *Erebia* an organized modern analysis of the individual species on which they can base further studies.

Erebia epipsodea Butler is appropriately known as the "Common Alpine". It is our most widely spread species, and in collections it far outnumbers all other species with the possible exception of *E. discoidalis* Kirby. The fact that it is an extremely variable species had given rise to the myth that it was devoid of subspecific variation, an idea so widely accepted that such a distinct race as *E. e. remingtoni* Ehrlich remained undescribed years after its characteristics had been noted and it had been figured in color in our most popular book on butterflies (Holland, 1931). Recently two additional subspecies have been described,[1] demonstrating that *epipsodea* shows as much geographic variation in North America as any *Erebia*.

HISTORICAL BACKGROUND

Since the description of *epipsodea* by Butler in 1868, the literature on the species has been characterized by short notes on distribution and biology, both in periodicals and books. A brief glance at the synonymies will suffice to explain to the reader why the author has not attempted a detailed discussion of material published.

*Contribution No. 883 from Department of Entomology, University of Kansas, Lawrence.
1. Ehrlich, 1954, Journal of the Kansas Entomological Society, vol. 27, p. 80.

Materials and Methods

The author has personally examined over 1600 specimens of *epipsodea* and has received data from an unknown additional number. The work is based largely on the author's collection of some 500 specimens, probably the most comprehensive in existence, supplemented by extensive material from the American Museum of Natural History, the Canadian National Collection, and the collection of F. M. Brown. The large collection of C. F. dos Passos was consulted, but was not worked on in detail as was the aforementioned material. The material in several smaller collections was also examined.

In order to be able to present a unified discussion of the distribution and subspeciation of *epipsodea* the whole picture has been discussed in detail at the end of the paper, and only briefly under the individual subspecies. Each subspecies is first treated separately in order to prevent nomenclatorial confusion.

All measurements are length of one primary wing, base of subcosta to apex in millimeters, taken to the nearest millimeter.

Acknowledgments

The author wishes to thank the following people who kindly supplied him with specimens, data, and/or advice: J. B. Baker, C. Bird, K. Bowman, P. F. Bruggemann, F. M. Brown, O. Buchholz, H. K. Clench, H. de Lesse, C. F. dos Passos, J. D. Eff, T. N. Freeman, A. G. Gabriel, N. W. Gillham, W. A. Hammer, J. C. Hopfinger, R. Leuschner, L. M. Martin, E. G. Munroe, Mr. and Mrs. F. W. Preston, C. L. Remington, P. S. Remington, D. B. Stallings and J. B. Ziegler.

The author is most grateful to Dr. Alexander B. Klots, Research Associate of the American Museum of Natural History, Mr. F. Martin Brown of Colorado Springs, and Dr. R. R. Sokal of the Department of Entomology, University of Kansas, all of whom have given very extensive assistance on many facets of the work. Finally the author wishes to express his deep appreciation to Dr. F. H. Rindge, Curator of Lepidoptera of the American Museum, who gave up much of his valuable time to read this manuscript and to give advice on a great many taxonomic problems.

SYSTEMATIC DESCRIPTIONS

Erebia epipsodea is easily identified by both the facies and the genitalia. Its habitus is actually unlike that of any other Nearctic *Erebia,* but as a result of superficial examination an occasional

specimen of *Erebia disa* Thunberg has found its way into series of *epipsodea*. Any specimen of *epipsodea* should be determinable without resort to genitalic dissection through the use of the plates and descriptions of the present paper or of any other work which deals with the Nearctic *Erebia*. However if it should prove necessary to employ the genitalia to determine the specimen, the following distinctions should serve: in the male, *epipsodea* is the only Nearctic species with a toothed juxta and aedeagus; in the female, it is the only Nearctic species with a greatly reduced clapet (the scooplike projection of the genital plate which is characteristic of a great many *Erebia*).

A total of 71 genitalic preparations of *epipsodea* have been made by the author, including both sexes of all subspecies. No significant intersubspecific differences have been found.

The life history of *epipsodea* was described by Edwards in 1897, in his "Butterflies of North America" (3rd series, *Erebia* 3). Habits and habitat will be discussed under the individual subspecies.

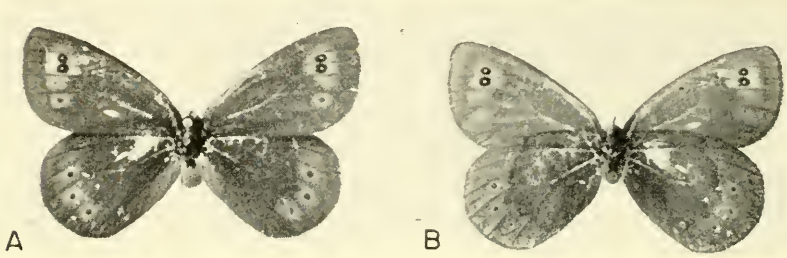
Erebia epipsodea epipsodea Butler

Figs. 1A, 1B, 2A, 2B, 3A, 3B

Erebia epipsodea Butler, 1868, Catalogue of diurnal Lepidoptera . . . family Satyridae in the . . . British Museum, p. 80, pl. 2, fig. 9; Edwards, 1872, Synopsis of North American butterflies, p. 26; Edwards, 1877, Trans. Amer. Ent. Soc., vol. 6, p. 34; Edwards, 1884, *ibid.*, vol. 11, p. 289 (*partim*); Edwards, 1897, Butterflies of North America, 3rd series, *Erebia* 3, figs. 1-5, a-g (*partim*), *op. cit.*, supplementary notes; Mead, 1875, *in* Wheeler, report upon geographical explorations and surveys . . . vol. 5, p. 775; Scudder, 1875, Bull. Buffalo Soc. Nat. Sci., vol. 2, p. 243; Strecker, 1878, Butterflies and moths of North America, p. 151; Strecker, 1879, *in* Ruffner, Annual report upon explorations and surveys in the department of the Missouri, appendix, S. S. of the annual report of the Chief Engineers for 1877, p. 1856; Elwes, 1889, Trans. Ent. Soc. London, p. 326 (*partim*); Elwes, 1898, *ibid.*, p. 190; Cockerell, 1890, Ent. News, vol. 1, p. 58; Maynard, 1891, A manual of North American butterflies, p. 114 (*partim*); Skinner, 1898, A synonymic catalogue of North American Rhopalocera, p. 36; Skinner, 1905, *ibid.*, supplement no. 1, p. 14; Chapman, 1898, Trans. Ent. Soc. London, p. 230, pl. 14, fig. 43; Holland, 1898, The butterfly book, p. 210, pl. 25, fig. 28 (*partim*); Holland, 1915, The butterfly guide, p. 133, pl. 66, fig. 2 (*partim*); Holland, 1931, The butterfly book, revised ed., p. 204, pl. 25, fig. 28, pl. 61, figs. 25, 26 (*partim*); Dyar, 1902, Proc. Ent. Soc. Washington, vol. 5, p. 129; Dyar, "1902" (1903), Bull. U. S. Natl. Mus., vol. 52, p. 29 (*partim*); Wright, 1906, The butterflies of the West Coast, p. 190 (*partim*); Elrod, 1906, The butterflies of Montana, p. 114, figs. 87, 88; Oberthür, 1909, Études de Lepidopterologie comparée, vol. 3, p. 295; Weymer, 1911, *in* Seitz, Macrolepidoptera of the world, vol. 5, p. 238, pl. 51e (*partim*); Blackmore, 1927, Checklist of the Macrolepidoptera of British Columbia, p. 8 (*partim*); Klots, 1930, Bull. Brooklyn Ent. Soc., vol. 25, p. 156; Klots, 1951, A field guide to the butterflies, p. 76 (*partim*); Gaede, 1931, *in* Strand, Lepidopterorum Catalogus, p. 554 (*partim*); Warren, 1936, Monograph of the genus *Erebia*, p. 239, pl. 38, fig. 358, pl. 83, figs. 1164, 1170, 1171 (*partim*); Cross, 1937, Proc. Colorado Mus., vol. 16, p. 11; Davenport and

Dethier, 1937, Ent. Americana (new series), vol. 17, p. 169; dos Passos, 1939, Bull. Cheyenne Mountain Mus., vol. 1, pt. 2, p. S-13; dos Passos, 1951, Jour. New York Ent. Soc., vol. 56, p. 161; Brown, 1942, Colorado College Publication, general series no. 233, p. 17; Brown, "1951" (1952), Lepidopterists' News, vol. 5, p. 119; Eff, 1947, Lepidopterists' News, vol. 1, p. 91; Eff, "1948" (1949), *ibid.*, vol. 2, supplement, p. iv; Eff, "1949" (1950), *ibid.*, vol. 3, p. 92; Eff, "1951" (1952), *ibid.*, vol. 5, p. 92; C. L. Remington, 1948, Lepidopterists' News, vol. 2, p. 37; Remington, 1952, Psyche, vol. 59, p. 66; de Lesse, 1949, Rev. Francaise d'Entomologie, vol. 16, p. 181; Bowman, 1951, Canadian Jour. Zool., vol. 29, p. 130 (*partim*); Jones, 1951, Ent. Soc. British Columbia, occasional paper no. 1, p. 9 (*partim*); Ehrlich, 1952, Ent. News, vol. 63, p. 225; P. S. Remington, "1952" (1953), Lepidopterists' News, vol. 6, p. 103.

Maniola epipsodea, Kirby, 1871, A synonymic catalogue of diurnal Lepidoptera, vol. 1, p. 65.



Photographs by C. F. dos Passos.

FIG. 1. *Erebia epipsodea* Butler, type, Rocky Mountains. A. Upper side. B. Under side.

Erebia Rhodia Edwards, 1871, Trans. Amer. Ent. Soc., vol. 3, p. 273; Edwards, 1872, List of species collected . . . *in* Hayden, Preliminary report of U. S. Geological Survey of Montana and adjacent territory, fifth annual report of progress, p. 467; Brown, 1934, Jour. New York Ent. Soc., vol. 42, p. 161; Ehrlich, 1952, Ent. News, vol. 63, p. 230.

Erebia epipsodea var. *rhodia*, Saunders, 1885, Trans. Royal Soc. Canada, sect. 4, p. 98.

Erebia epipsodea? var. *brucei* Elwes, 1888, Trans. Ent. Soc. London, p. 326; Elwes, 1898, *ibid.*, p. 190; Edwards, 1897, Butterflies of North America, 3rd series, *Erebia* 3, figs. 6, 7; Weymer, 1911, *in* Seitz, Macrolepidoptera of the world, vol. 5, p. 238; Warren, 1936, Monograph of the genus *Erebia*, p. 241, pl. 83, fig. 1171; Cross, 1937, Proc. Colorado Mus., vol. 16, p. 11; Davenport and Dethier, 1938, Ent. Americana (new series), vol. 17, p. 169; Ehrlich, 1952, Ent. News, vol. 63, p. 230.

Erebia brucei, Holland, 1931, The butterfly book, revised ed., p. 204, pl. 61, fig. 20.

Male: length of one primary wing 19-24 mm., average (152 specimens) 21.7 mm.

Above, ground color light to deep chocolate brown. Primaries with deep orange-brown submarginal patches. Patches in cells R_5, M_1, M_2, M_3, Cu_1, narrowest in cell Cu_1, widening craniad with widest in cell M_2, then narrowing slightly to cell R_5. Largest patch 3-6 mm. wide. Patches in cells M_1, M_2, M_3, and Cu_1, usually

enclosing black ocelli. Subapical ocelli (those in cells M_1 and M_2) always pupilled with white, sometimes fused. Ocellus in cell M_3 smallest, rarely pupilled, sometimes absent. Ocellus in cell Cu_1 smaller than subapical ocelli, sometimes pupilled, rarely absent. Veins separating patches ground color, patch in cell Cu_1 sometimes separated from other patches by a wide strip of ground color along vein Cu_1. Outline of patches varying in sharpness, sometimes very indefinite. Secondaries with submarginal patches in cells M_1, M_2, M_3, and Cu_1. Patches concolorous with those on primaries. Patch in cell M_1 often reduced, very indefinite, or absent. Largest patch in cell M_2, with those in cells M_3 and Cu_1 progressively smaller. Black ocelli of varying size, often pupilled with white, are found in patches of cells M_2, M_3, and Cu_1; patch in cell M_1 rarely with an ocellus, never with a pupilled ocellus. Patches often reduced to rings around the ocelli.

Below, ground color a duller and lighter brown than above. Primaries with patches suffused with ground color, especially in cells R_5, M_3, and Cu_1. Subapical ocelli reproduced as above. Ocellus in cell M_3 absent, that in cell Cu_1 absent or represented by a black point. Apex and sometimes outer margin flecked with gray scales. Secondaries traversed by a dark brown discal band, crenate distad, irregular basad. Prominence of the band varying with the amount of gray scaling in the basal and limbal areas. Patches reduced to light rings around the ocelli. Ocelli in cells M_2, M_3, and Cu_1 usually present but extremely variable in size, ocellus in cell M_1 less frequently present. Pupilling very varied. In some specimens there is a faint dark marginal band. Fringes concolorous with ground color.

Head, thorax and abdomen brown-black. Antennae above brown, flecked with white scales; below white with yellow brown club.

Female: length of one primary wing 20-23 mm., average (34 specimens) 21.6 mm.

Above, ground color and patches somewhat lighter than in the male. Ocelli larger and more heavily pupilled. Rarely with a black point in cell R_5 and/or Cu_2.

Below, ground color slightly lighter than above. Ocelli reproduced below as in male. Basal and limbal areas of secondaries and veins of discal area scaled with gray. Discal band not much more prominent than in male because of its lighter color.

Otherwise similar to male.

Erebia epipsodea epipsodea is found from the high mountains of northern New Mexico north in the Rockies to western Alberta and eastern British Columbia (see map). It occurs in the Hudsonian, Canadian, and upper Transition zones. It is found in small numbers in the arctic-alpine zone, but Brown states (*in litt.*) "I have a strong suspicion that where they (*epipsodea*) are abundant at treeline you will always find that the treeline is false . . . In many places in the state (Colorado) the treeline has been artificially depressed by snowslides or avalanches." In Colorado *E. e. epipsodea* occurs in open grasslands and less frequently in sage flats. It is found over the western part of the state above 7,000 feet up to 11,800 or 12,000 feet, chiefly between 8,500 and 10,000 feet. In general in Colorado *epipsodea* flies in June around 8,500-9,000 feet, July around 11,000, and extends well into August at 12,000 feet. The interesting aberration of *epipsodea* which has no ocelli on the upper surface (*brucei* Elwes) is found mainly at high elevations in Colorado. Mr. and Mrs. F. W. Preston found it quite frequent among typical *epipsodea* just below the summit of Loveland Pass at an elevation of about 11,950 feet, in early August of 1952. It was impossible to separate the *brucei* from the *epipsodea* in flight, and they appeared to be randomly distributed in the *epipsodea* population. Some 66 *epipsodea* and 11 *brucei* were taken in three days, but these numbers indicate a larger proportion of *brucei* than was actually present as some seconds of *epipsodea* were released. The Prestons kindly sent the author two of the *brucei* which they captured and a series of the *epipsodea* from the same locality. Among the latter the author was pleased to find two males which are definitely transitional to *brucei.*

In southern Wyoming, Klots (1930) found *epipsodea* in the lower and upper Canadian zone (8,500-9,600 feet) in late June and early July in small glades in the forest, and more abundantly in the open meadows above the forest belt. The author has before him fresh specimens taken in Albany county in southern Wyoming at 7,500 feet in early July, and in Sheridan and Johnson counties in northern Wyoming at 7,800 feet, also in early July. Almost all of the material which has been seen from Yellowstone National Park has been taken in July. An interesting series in the author's collection from Kiowa, Montana, just east of Glacier National Park, dated July 10, 1952, consists of 15 worn and battered males and a

single fresh female, indicating a much earlier emergence. Banff, Alberta specimens seem to be taken mainly in mid-July.

Butler (1868) gives the type locality of *Erebia epipsodea* as "Rocky Mountains." This unfortunately is not sufficiently restricted for modern systematic work, and so every effort has been made to discover more exactly the area where the type was captured. Due to the great individual variations of *epipsodea* the type itself cannot be accurately placed in one of the subspecies on the basis of its facies. Mr. A. G. Gabriel, Senior Scientific Officer of the Department of Entomology of the British Museum (Natural History) kindly looked up the registration of the type and found that it was one of 50 butterflies presented to the Museum by the Earl of Derby in 1845. The present Earl of Derby (*in litt.*) informed the author that he had no information on where or how his ancestor had obtained the specimens. Mr. Gabriel, however, was able to discover four of the original 50 butterflies in the British Museum collection. They were a pair of *Colias christina* Edwards, a female *Colias skinneri* Barnes, and a female *Speyeria eurynome* Edwards. On consultation with Dr. Alexander B. Klots, one of our foremost authorities on the Nearctic Rhopalocera the following was decided: assuming that the above specimens were taken in the same general area as the type of *epipsodea* then the type locality of *epipsodea* would be somewhere in the area from Red Desert gap in the Rockies in southern Wyoming north to Jasper National Park in the Canadian Rockies. Because of the great separation of *christina* and *skinneri* in Montana there is a little better evidence for the eastern side of the divide in the Canadian Rockies north to Jasper. This hypothesis is supported by the fact that it seems improbable that specimens would be reaching England in 1845 from the far northern Rockies or the Cascades. As will be discussed later, material from that part of the Canadian Rockies is somewhat transitional, but appears to be closest to the subspecies from Colorado, therefore in this paper *Erebia epipsodea epipsodea* is the name applied to the subspecies which ranges from Colorado north, and typical *epipsodea* will be considered as coming from Colorado.

Erebia rhodia Edwards was described from Colorado and is therefore a synonym of *Erebia epipsodea epipsodea* Butler. *Erebia epipsodea*? var. *brucei* Elwes described from Summit county, 12,000 feet, Colorado is an aberration and is also a synonym of *E. e. epipsodea.*

Erebia epipsodea remingtoni Ehrlich

Figs. 2C, 2D, 3C, 3D

Erebia epipsodea, Holland, 1898, The butterfly book, p. 210 (*partim*); Holland, 1900, Ent. News, vol. 11, p. 387; Holland, 1915, The butterfly guide, p. 133 (*partim*); Holland, The butterfly book, revised ed., p. 204, pl. 61, figs. 24, 27 (*partim*); Dyar, "1902" (1903), Bull. U. S. Natl. Mus., vol. 52, p. 29 (*partim*); Weymer, 1911, *in* Seitz, Macrolepidoptera of the world, vol. 5, p. 238 (*partim*); Gibson, 1920, Report of the Canadian Arctic expedition 1913-18, vol. 3, pl. I, p. 18i; Gaede, 1931, *in* Strand, Lepidopterorum Catalogus, p. 554 (*partim*); Warren, 1936, Monograph of the genus *Erebia*, p. 241 (*partim*); McDunnough, 1937, Canadian Ent., vol. 69, p. 18; Jones, 1951, Ent. Soc. British Columbia, occasional paper no. 1, p. 9 (*partim*); Klots, 1951, A field guide to the butterflies, p. 76 (*partim*).

Erebia epipsodea remingtoni Ehrlich, 1952, Ent. News, vol. 63, p. 225; P. S. Remington, "1952" (1953), Lepidopterists' News, vol. 6, p. 105.

Male: length of one primary wing 21-22 mm., average (14 specimens) 21.6 mm.

Female: length of one primary wing 20-22 mm., average (7 specimens) 21.1 mm.

E. e. remingtoni differs from *E. e. epipsodea* in the reduction in size and number of the ocelli on both surfaces of both sexes. Approximately half of the males of this subspecies have no ocelli on the underside of the secondaries, and the discal band is often very dark and prominent. The number of white pupilled ocelli are also greatly reduced in the males, with the subapical "ocelli" sometimes being merely black disks. The patches in the males are very variable, and are occasionally reduced to traces on the upperside of the secondaries.

Erebia epipsodea remingtoni has thus far been seen from the extreme northwestern corner of British Columbia; southeastern Yukon Territory; along the Yukon River Valley from Dawson, Yukon Territory, to Fort Yukon, Alaska, on the Arctic Circle; and central Alaska from the Yukon border to Fairbanks.

According to Bruggemann (*in litt.*), *remingtoni* in the Dawson area flies "in meadows, both dry and wet, open, grassy hillsides, along roads and in grassy openings in the woods, both deciduous and coniferous, up to elevations of about 4000 feet". The dates of the type series run from June 11 to August 22.

This is the most distinct of the subspecies of *epipsodea*. It was described by the present author (1952) from 121 specimens, from a number of British Columbian, Yukon, and Alaskan localities. The type locality is Dawson, Yukon Territory. Since the description, several more specimens and records have come to light (see map), including 10 males and a female from Eagle, Alaska, in

the collection of the Los Angeles County Museum. Mr. Lloyd M. Martin has examined these specimens, and writes that they are typical of the subspecies. Two records given by Edwards (1897) are believed to be referable to *Erebia disa* ssp. These are St. Michaels and Nushagak, Alaska.

Erebia epipsodea hopfingeri Ehrlich

Figs. 2E, 2F, 3E, 3F

Erebia epipsodea, Elwes, 1889, Trans. Ent. Soc. London, p. 326 (*partim*); Maynard, 1891, A manual of North American butterflies, p. 114 (*partim*); Edwards, 1897, Butterflies of North America, 3rd. series, *Erebia* 3 (*partim*); Wright, 1906, The butterflies of the West Coast, p. 190, pl. 24, fig. 262 (*partim*); Blackmore, 1927, Checklist of the Macrolepidoptera of British Columbia, p. 8 (*partim*); Warren, 1936, Monograph of the genus *Erebia*, p. 241, pl. 38, fig. 357, pl. 83, figs. 1163, 1165, 1169 (*partim*); Leighton, 1946, Univ. of Washington Publ. Biol., vol. 9, p. 55; Hopfinger, "1948" (1949), Lepidopterists' News, vol. 2, supplement, p. iii; Hopfinger, "1949" (1950), *ibid.*, vol. 3, p. 88; Hopfinger "1950" (1951), ibid., vol. 4, p. 93.
Erebia epipsodea hopfingeri Ehrlich, 1954, Jour. Kansas Ent. Soc., vol. 27, p. 80.

Male: length of one primary wing 22-25 mm., average (30 specimens) 23.5 mm.

Female: length of one primary wing 23-25 mm., average (16 specimens) 24.3 mm.

E. epipsodea hopfingeri is characterized by its large size, proportionately small patches, and very dark chocolate brown ground color. It is separated from *E. e. epipsodea* by these characters, and from *E. e. remingtoni* by its complete set of ocelli and to a lesser degree by the above characters. It is consistently larger than *remingtoni* but sufficient fresh material of *remingtoni* is not available to make a comparison of ground colors feasible.

Type Material: Holotype male and allotype female, Black Canyon 1000 feet, South of Methow, Okanogan County, Washington, May 24, 1952 (J. C. Hopfinger). There are 53 male and 13 female paratypes as follows: 20 males and seven females, Black Canyon, 1000 feet, South of Methow, Okanogan County, Washington, May, June (various dates) 1944, 1946, 1952 (J. C. Hopfinger); six males (genitalic slides nos. 13 and 83, P. R. Ehrlich), Tiffany Lake 7000 feet, Northwest of Conconully, Okanogan County, Washington, June, July (various dates) 1947, 1949 (J. C. Hopfinger); one male, Gold Creek, Washington, June 27, 1943 (J. D. Eff); two males, Gold Creek, Washington, June 18, 1944; one male and one female, Spokane Falls, Washington Territory, May 30, 1882 (Stretch); one male, Brewster, Okanogan County, Washington, June 10, 1944 (W. A. Hammer); 17 males (genitalic slides nos. 91, 92, 93, and 94, P. R. Ehrlich) and four females (genitalic slide no. 87, P. R. Ehrlich),

Brewster, Washington, May, June (various dates) 1938, 1947, 1949, 1952 (J. C. Hopfinger); three males and one female, Wallowa Lake, Wallowa National Forest, Oregon, July 23, 1940 (J. H. Baker); one male, Wallowa Lake, Oregon, June 30, 1938; one male, same locality, July 26, 1949. The holotype and allotype are in the American Museum of Natural History, *ex* collection P. R. Ehrlich. Of the above paratypes five males and four females are in the collection of J. C. Hopfinger and one male is in the collection of J. D. Eff. The remaining paratypes are in the collection of the author, some of which will be distributed.

E. epipsodea hopfingeri has been seen from eastern Washington, northeastern Oregon, south-central British Columbia and northwestern Idaho. Because of the uncertainty of the extent of the subspecies in Idaho and British Columbia (to be discussed later) only Oregon and Washington specimens have been included in the type series.

The author was pleased to name this subspecies after his friend, Mr. John C. Hopfinger of Brewster, Washington, who collected most of the type series.

Erebia epipsodea freemani Ehrlich

Figs. 2G, 2H, 3G, 3H

Erebia sine-ocellata Skinner, 1889, Canadian Ent., vol. 21, p. 239; Aaron, 1890, Ent. News, vol. 1, p. 12; Edwards, 1897, Butterflies of North America, 3rd series, explanation of pl. *Erebia* 3; Ehrlich, 1952, Ent. News, vol. 13, p. 230.
Erebia epipsodea, Lyman, 1896, Canadian Ent., vol. 28, p. 274; Cary, 1906, Proc. U. S. Natl. Mus., vol. 31, p. 448; Turner, 1906, Ent. Monthly Magazine, vol. 42, p. 119; Turner, 1906, The Entomologist, vol. 39, p. 165; Brodie, 1929, Trans. Royal Canadian Institute, vol. 17, part 1, p. 83; Gaede, 1931 *in* Strand, Lepidopterorum Catalogus, p. 554 (*partim*); Warren, 1936, Monograph of the genus *Erebia*, p. 241 (*partim*); Brooks, 1942, Canadian Ent., vol. 74, p. 33; Bowman, 1951, Canadian Jour. Zool., vol. 29, p. 130 (*partim*); Klots, 1951, A field guide to the butterflies, p. 76 (*partim*).
Erebia episodea (sic), Turner, 1906, The Entomologist, vol. 39, p. 142.
Erebia epipsodea freemani Ehrlich, 1954, Jour. Kansas Ent. Soc., vol. 27, p. 80.

Male: length of one primary wing 19-23 mm., average (54 specimens) 21.3 mm.

Female: length of one primary wing 20-22 mm., average (14 specimens) 21.1 mm.

This subspecies differs from the other three subspecies of *epipsodea* in the lighter orange color and sharper outline of the patches. The sharper outline is especially evident on the underside of the females. *E. e. freemani* is the brightest in habitus of the four subspecies of *epipsodea*. The females often have a very heavy gray overscaling on the underside of the secondaries.

Type Material: Holotype male, Lloydminster, Alberta, June 8, 1946 (P. F. Bruggemann); allotype female, same locality, June 13, 1948 (P. F. Bruggemann). There are 60 male and 17 female paratypes as follows: 15 males and seven females (genitalic slides nos. 28 and 49, P. R. Ehrlich), Lloydminster, Alberta, June 1-13, 1944, 1946, 1947, 1948 (P. F. Bruggemann); 10 males (genitalic slides nos. 96, 97, and 98, P. R. Ehrlich) and one female, Harlan, Saskatchewan, June 8-14, 1939, 1946, 1947 (P. F. Bruggeman); one male and one female, Rivercourse, Saskatchewan, June 10, 25, 1940; six males and one female, Attons Lake, Cut Knife, Saskatchewan, June 8-9, 1940 (A. B. Brooks); one female, Cravan, Saskatchewan, June 27, 1920 (C. H. Young); one male and one female, Starblanket, Saskatchewan, May 27, June 1; seven males and four females, Miniota, Manitoba, June 3-10, 1919, 1921 (H. Gibbon); three males, same locality and collector, no dates; seven males (genitalic slide no. 99, P. R. Ehrlich), Beulah, Manitoba, June 10-July 16; seven males, McCreary, Manitoba, June 10-July 10, 1928, 1931; three males and one female, Manitoba, Canada. The holotype and allotype are in the American Museum of Natural History, *ex* collection P. R. Ehrlich. Of the above paratypes seven males and one female are in the collection of the American Museum of Natural History, 13 males and three females are in the Canadian National Collection, four males are in the collection of the Academy of Natural Sciences of Philadelphia, three males are in the collection of Otto Buchholz, one male is in the collection of F. M. Brown, *ex* collection A. M. N. H., *ex* collection P. R. Ehrlich, one male is in the collection of J. D. Eff, *ex* collection A. M. N. H., *ex* collection P. R. Ehrlich, and one male is in the collection of J. C. Hopfinger, *ex* collection P. R. Ehrlich. The remaining paratypes are in the collection of the author, some of which will be distributed.

E. epipsodea freemani is the subspecies of the Canadian Prairie-Parkland. According to Bruggemann (*in litt.*) it is the commonest Satyrid in the Lloydminster district, flying in June along the roads, in pastures (both dry and wet), on grassy hill sides and along the margins of poplar "bluffs". Farther north at Harlan, Saskatchewan, where the main feature of the vegetation is an outlier of the northern coniferous forest, *freemani* flies at the same time and in the same habitats as at Lloydminster but is slightly less numerous. It occurs also on the grassy muskegs, but never inside the stands of conifers, where it is replaced by *E. disa mancina* Hewitson, which is rarely, if ever, encountered in the

open. The subspecies also flies at Cold Lake (80 miles due north of Lloydminster) at the edge of, and around Primrose Lake (100 miles due north of Lloydminster) within the northern coniferous forest, in habitats similar to those around Harlan. Bruggemann (*in litt.*) states "As a rule only the males are seen flying, rather leisurely, but somewhat erratically. As is the case with several other northern Satyrids, e. g. *Oeneis alberta alberta* Elwes and Edwards, *O. uhleri varuna* Edwards, and *Erebia discoidalis* Kirby, the females are sluggish fliers and, when fully gravid, often unable to take off".

The subspecies has thus far been seen from southwestern Manitoba, the southern two thirds of Saskatchewan and the southern plains of Alberta. Because of the uncertainty of the extent of the subspecies in Alberta only Saskatchewan and Manitoba specimens have been included in the type series.

The subspecies was named in honor of Dr. T. N. Freeman, co-ordinator of the Northern Insect Survey, as a slight token of appreciation of his many favors.

Erebia sine-ocellata Skinner was described as a "var. of *epipsodea*" from a specimen taken at Fort Qu'Appelle, Saskatchewan and a specimen without data. From the discussion of the variation of *epipsodea* which is included in the short original description it is obvious that *sine-ocellata* was described as an individual variant [2], and all subsequent workers have considered it an aberration, usually as a synonym of *brucei* Elwes. The type specimen is, indeed, a transition towards *brucei*. Because of the ineptness of the name and because the type of the subspecies would be an aberrational specimen, *sine-ocellata* was not considered available and *freemani* was proposed for the new subspecies.

GEOGRAPHICAL VARIATION

Because of the tremendous individual variation exhibited by *epipsodea* it was necessary to assemble large numbers of specimens before any significant geographical variation could be discerned. Anyone familiar with the species knows that no two series are just alike, and material from one locality may be quite different from material from another locality a few miles away. Thus the problem has been to disregard the minor extrinsic variations and to discover the broader trends of (theoretically) genetic

2. *See* Bull. Zoo. Nomencl., vol. 10, pp. 438-445, 1953.

variation. The criteria employed to differentiate between the two types of variation are mainly those of Mayr, who states [3]

"There is frequently one good indicator which permits us to differentiate phenotypical from geographic-racial characters. The geographic race has, in general, a fairly wide range, including a number of different habitats. The phenotypical variant, on the other hand, usually has a rather small range at any one locality, but crops up again and again wherever the same or a similar combination of environmental factors occurs".

Each of the four races delimited in this paper fulfills the above requisites.

One of the first characters studied was size as indicated by the length of one primary wing. Table 1 shows sample sizes, mean lengths and standard errors of this character for series of male *epipsodea* from 14 localities. In several cases small series from several localities were combined into a single series for this analysis. These were: Miniota, Manitoba, which contains specimens from Miniota, Beulah, and McCreary, Manitoba; Brewster, Washington, which contains specimens from Brewster, Black Canyon, and Tiffany Lake, Washington; Jesmond, British Columbia, which includes specimens from Jesmond, Pavilion Lakes, Clinton, and Lilloet, British Columbia; Osoyoos, British Columbia, which includes specimens from Osoyoos, Summerland, Penticton, Hedly, Keremeos, and Grand Forks, British Columbia; and Kamloops, British Columbia, which includes specimens from Kamloops, Vernon, and Salmon Arm, British Columbia. On entering the locality means on a map, it is evident that the size of the individuals tends to increase as one goes from east to west.

On subjecting these means to an analysis of variance a highly significant F value ($F = 26.23$ indicating $P << .01$) was found. This would indicate that there is true differentiation between the localities with respect to wing length. It was estimated that 52.28% of the total variance of size in the study is attributable to differences between localities.

The individual means in the analysis were then analysed by methods proposed by Tukey.[4] These methods deal with establishing significance between means and groups of means in an analysis of variance, taking into account the fact that the tails of any normally distributed array of means would appear significantly different if examined by customary t-tests. A rigorous significance level of $P < .01$ was adopted.

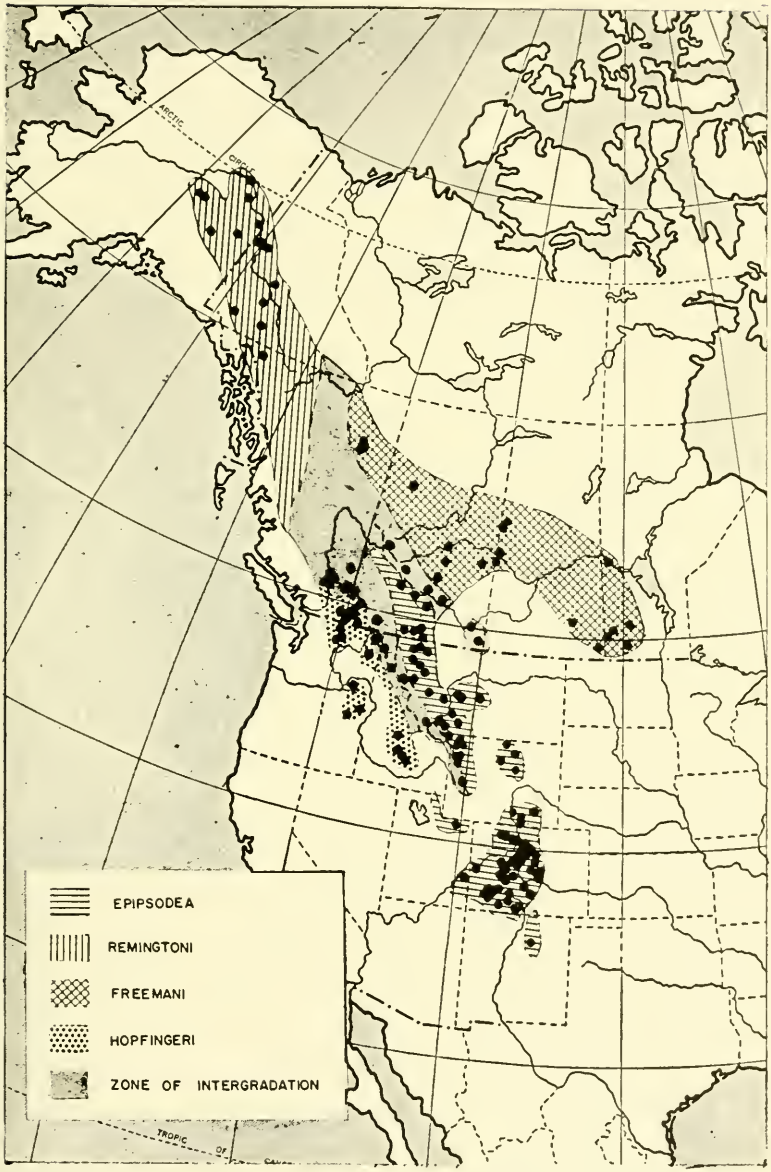
3. 1942. Systematics and the origin of species, p. 63.
4. Biometrics 5: 99-114, 1949.

The following groups were found: group 1, subgroup 1—Hall Valley, Miniota, Harlan; group 1, subgroup 2—Didsbury, Tolland, Banff, Rock Creek, Glacier; group 2—Wallace, Cranbrook, Jesmond, Osoyoos, Brewster, Kamloops. The means are arrayed above in order of increasing size from Hall Valley to Kamloops. The longest gap in the array is between groups 1 and 2; the other gap, between subgroups 1 and 2 of group 1 is shorter, although still significant. Analyses of variance of the segregates gave the following results: group 1, subgroup 1—$F = 4.35$, $P > .05$; group 1, subgroup 2—$F = 1.45$, $P > .05$; group 2—$F = 1.94$, $P > .05$. It is thus seen that there is no significant differentiation between means within these groups.

Biologically the author would draw the following conclusions from these data. First that there are two areas of steep gradient in the general east-west (small-large) size cline; the first around eastern Alberta and the second in the eastern half of the southern arm of the area marked "zone of intergradation" on the map accompanying this paper. Second that the type series of *hopfingeri* was drawn from the area of maximum size of the species, and that large size is a valid character for this subspecies. It should be noted, however, that certain other populations whose mean size was not significantly different from *hopfingeri* (Brewster) have been placed in the zone of intergradation on the basis of other characters. Finally it is the author's opinion that the Hall Valley specimens represent a specialized high altitude form. In summary, although the pattern of size variation in the populations studied supports the author's subspecific arrangement in a general way, there is no exact concordance.

Before continuing with the discussion of geographic variation in *epipsodea* it would be best to explain the map which accompanies this paper. The map shows a black dot for each record of *epipsodea,* without regard for subspecies; the shaded areas show the theoretical range of each subspecies taking into consideration life zones. The area marked "zone of intergradation" is an area from which we have but few specimens with insufficient data. Most of the specimens which the author has seen from this area are intermediates between two of the subspecies. The boundaries on the map are purely arbitrary, as it is doubtful if there are any natural intersubspecific boundaries in *epipsodea.*

The color, definition, and size of the patches are important geographically varying characters in *epipsodea.* In specimens from the Canadian prairies (*freemani*) a large percentage of the indi-



Map, courtesy of the McKinley Publishing Company.

Distribution of *Erebia epipsodea* Butler.

viduals have light colored patches. By dividing the material arbitrarily into specimens with light patches and specimens with dark patches the following results were obtained. Of 65 specimens from the prairies 70.8% had light patches, while of 445 specimens from the other populations of *epipsodea* only 2.5% had light patches (difference significant at $P << .001$). In the prairie specimens the patches also tended to be more clearly defined, with less suffusion of ground color around the edges. Of 14 prairie females 12 (85.7%) had clearly outlined patches on the underside of the secondaries, while of 47 females from other populations only 4 (8.5%) had clearly outlined patches (difference significant at $P << .001$), the remainder having the patches suffused with ground color and poorly defined.

The proportionately small size of the patches is a diagnostic character of *E. e. hopfingeri.* This will serve in most cases to separate *hopfingeri* from its closest relative *epipsodea.* However, material from Banff, Alberta in the author's collection is very similar to *hopfingeri* in this respect, although very close to *epipsodea* in all others. Because the type locality of *epipsodea* may fall in the Banff area it has been necessary to decide whether this intermediate material was closer to the Colorado or Washington races. Because in habitus the Banff material appears more like that from Colorado, and because it seems preferable to have the nominate subspecies in Colorado, from which State we have so much material, the author has included the Banff material in the Colorado subspecies under the name *epipsodea.*

The reduction or loss of ocelli is characteristic of *E. e. remingtoni.* The only indication that this character may fall into a cline is that a series of specimens from the Jesmond-Clinton, British Columbia area shows a maculation very similar to that of *remingtoni* while retaining the large, dark appearance of *hopfingeri.* Whether or not there is a series of *epipsodea* populations running northward through western British Columbia and more or less connecting this southern population with *remingtoni* at Atlin is not known. Much of this area has never been collected, and the author strongly suspects that such a link may exist. The map has been drawn to show this theoretical link as existing.

In using ground-color as a character the author has been limited to employing reasonably fresh specimens. Fortunately, where it was most important, recent specimens have been available. This is in the comparison of *epipsodea* to *hopfingeri.* In this case *hopfingeri* definitely is a darker insect.

Neither *hopfingeri* or *freemani* could be considered as a "strong" subspecies, and *hopfingeri* is probably the weaker of the two. However they both cover considerable geographic area and, in spite of the great individual variability of the species, are quite readily recognizable, especially in series. The problem of whether *hopfingeri* was merely a response to the lush environment of the Cascades and neighboring country has been one of no small magnitude. However the author feels that the combination of three characters, size, color, and patch size, plus its extensive range strongly indicate that *hopfingeri* has a genetic basis.

A DEVELOPMENTAL HYPOTHESIS

Erebia epipsodea appears to be one of our oldest *Erebia* residents. Its nearest relative in the Palearctic is probably *E. medusa* Schiffermüller and Dennis, but the two species are extremely distinct. *Erebia vidleri* Elwes has perhaps been in North America as long as, or longer than *epipsodea* since it is not considered as having close relatives in Asia. *Erebia magdalena* Strecker, *E. fasciata* Butler, and *E. youngi* Holland if not conspecific with Asiatic forms are at least very closely related to them (*E. erinnyn* Warren, *E. semo* Grum-Grshimailo [5] and *E. dabanensis* Erschoff respectively). The remaining Nearctic *Erebia*, *rossii* Curtis, *disa* Thunberg, *discoidalis* Kirby, *theano* Tauscher and *callias* Edwards are represented by subspecies in the Palearctic region.

It is assumed that the present distribution and subspecific pattern of *epipsodea* has come about since the last (Wisconsin) glaciation. On the basis of the present distribution of *epipsodea* races I would like to suggest the following pattern of subspeciation. At the height of the Wisconsin, *epipsodea* existed in a single race much like the Colorado subspecies today, somewhat to the south of the southern end of its present range. With the retreat of the ice, *epipsodea* split into three aggregates, one adapted to cold conditions advancing north along the main chain of the Rockies, and two adapted to more temperate conditions advancing northward through what is now the Great Basin and the Great Plains. With the warming and drying of these regions, *epipsodea* slowly died off in the southern ends of its range, partially or completely isolating the three populations in the northern end of the range. Because of the reduction or cessation of the gene flow between these

5. The status and distribution of the rare and often misidentified *Erebia avinoffi* Holland is still much in doubt.

populations they were able to evolve into three separate subspecies in response to their different environments. While *hopfingeri* moved into the Cascades and *freemani* spread through the Canadian plains, *epipsodea* continued to move north through the mountains, eventually evolving into *remingtoni* at the extreme northern end of its range. Finally *hopfingeri* and *freemani* moved in and made contact with the main *epipsodea-remingtoni* chain, resulting in the dilution of the subspecies and the formation of intermediate populations. The extent of gene flow between the four subspecies at the present time is not known, but since the species is not a strong flier it is probably rather sluggish.

TABLE 1.—LENGTH OF PRIMARY WING IN MALES

Series	N	Mean ± S. E. (in mm.)
Miniota, Manitoba	25	21.16 ± .125
Harlan, Saskatchewan	29	21.34 ± .159
Didsbury, Alberta	18	21.72 ± .195
Banff, Alberta	30	22.03 ± .155
Glacier National Park, Montana	17	22.29 ± .166
Rock Creek, Colorado	16	22.19 ± .188
Tolland, Colorado	30	21.87 ± .104
Hall Valley, Colorado	30	20.73 ± .166
Wallace, Idaho	17	22.76 ± .250
Brewster, Washington	30	23.47 ± .157
Cranbrook, British Columbia	30	22.97 ± .189
Osoyoos, British Columbia	30	23.33 ± .200
Kamloops, British Columbia	8	23.62 ± .263
Jesmond, British Columbia	15	23.00 ± .258

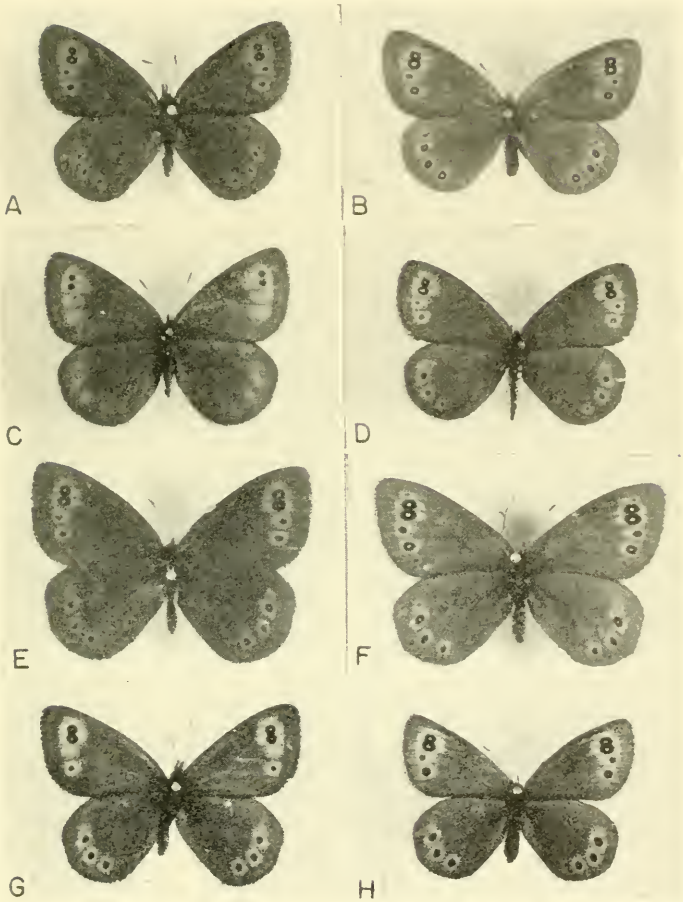


FIG. 2. Upper sides of specimens of *Erebia epipsodea*. A, B. *E. epipsodea epipsodea*. A. Male, Tolland, Gilpin county, Colorado. B. Female, same locality. C, D. *E. epipsodea remingtoni* paratypes. C. Male, Dawson, Yukon territory. D. Female, same locality. E, F. *E. epipsodea hopfingeri*. E. Holotype male. F. Allotype female. G, H. *E. epipsodea freemani*. G. Holotype male, H. Allotype female.

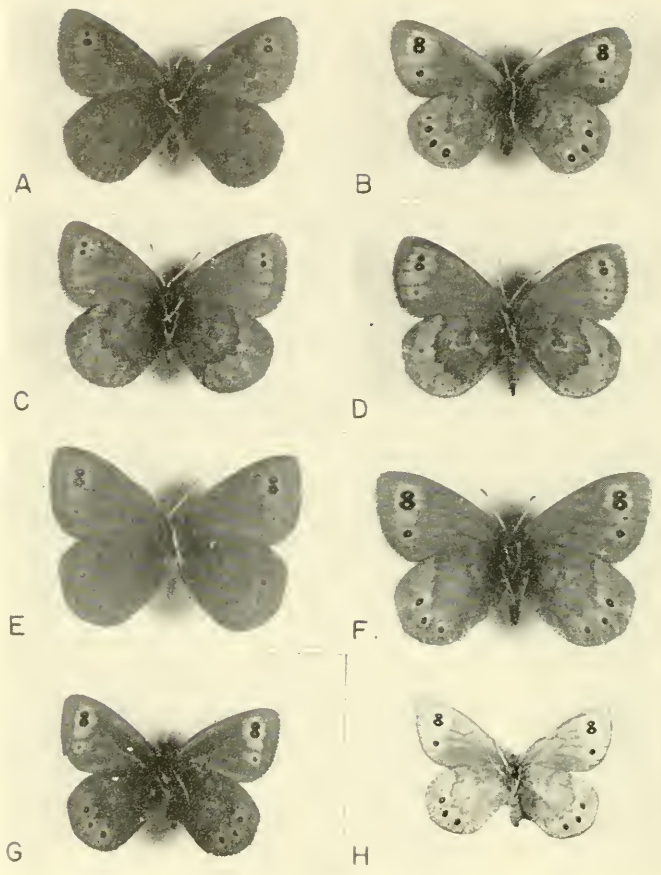


FIG. 3. Under sides of specimens shown in figure 2.

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Some Taxonomic and Morphological Studies of Two Genera of North American Dictyopharidae, (Fulgoroidea, Homoptera)

By KATHLEEN C. DOERING [1]

ABSTRACT: This paper deals with the taxonomy of two genera, *Deserta* Ball and *Acinaca* Ball and Hartzell of the subfamily Orgerinae (Dictyopharidae, Homoptera). A key to the North American genera of the subfamily Orgerinae is given. In the genus *Deserta* four older species have been redescribed and the genitalia of both sexes dissected and described in those species where material was available. Two species, *fuscata* and *pinturensis* are herein described as new. Two keys for identification of the six species of *Deserta* are given, one dealing with characters common to both sexes and one key for identification of male specimens only, based on characteristics of the male proctiger and genitalia. A synoptic table of the characteristics of the species of *Deserta* is also included. The genus *Acinaca* still remains, as far as our present knowledge goes, a monotypic genus. *Acinaca lurida* Ball and Hartzell has been redescribed, the genitalia of both sexes described and illustrated and new distribution records from New Mexico and Arizona are added to the one state record, namely California.

The characters of most value for classification in these two genera of Orgerinae are the shape and length of the head process, the increased size and development as well as shape of the flaplike extension of the tenth segment, the anal flap.

The morphological aspects of the paper include mainly a study of the genitalia and terminal abdominal segments. It is expected that other features of morphology studied but not specifically described in this paper will contribute to a larger and more comprehensive morphological paper dealing with the comparative morphology of the entire family.

INTRODUCTION

Since a very excellent and complete bibliography for each species of the insects studied in this paper has been given by Z. P. Metcalf in the General Catalogue of the Hemiptera, Fascicle IV, Fulgoroidea, Part 8, Dictyopharidae, 1946 it was deemed unnecessary to

1. Contribution number 885 from the Department of Entomology, University of Kansas

repeat these references. Therefore only such references that have appeared since this date have been included under each species heading. At the end of the paper are cited the references which have been most useful in this study.

Because of the bizarre appearance of some of the Orgerinae a drawing of the entire insect has been made for at least one species in each genus. As regards characteristics of taxonomic significance each species has been extensively illustrated. All drawings have been made to the same scale for a given character so that difference in size of drawings is significant.

In making the keys and descriptions certain specific measurements, not easily described in words, have been used. To indicate these the plan was adopted of placing double letters with a line drawn between showing the extent of the distance, on the key diagrams on Plate I. In the keys the measurement was referred to by stating the letter combination, such as a-a, b-b, etc. Single letters on the diagrams represent particular points mentioned in a key or description.

KEY TO NORTH AMERICAN GENERA OF ORGERINAE
(Modified from Ball and Hartzell)

1. Callosity behind eye; vertex elongate or angulate 2
   No callosity behind eye; head rounded or if elongate, scimitar-shaped if seen from the side 5

2.(1) Vertex elongate, produced in front of eye more than one half its length 3
   Vertex angulate, produced in front of eye not more than one half its length ..... *Orgerius* Stål

3.(2) Cephalic process truncate at the extremity; apical plate of process large, pentagonal, its length almost as wide as eye 4
   Cephalic process as seen from the side, beaklike, the apex obliquely rounding from above, the lower angle slightly produced; apical plate reduced, its length much less than width of eye ..... *Deserta* Ball & Hartzell

4.(3) Cephalic process gradually tapering as seen from both top and side; apex as seen from side slightly rounded, *Orgamara* Ball
   Cephalic process parallel-margined; apex as seen from side squarely truncate and slightly enlarged, *Yucanda* Ball & Hartzell

5.(1) Vertex angulate, produced in front of the eyes at least one third its length 6
   Vertex broad and short, scarcely longer than its basal width; the lateral carina of the front closely margins the eye clear to its juncture with the lateral margin of the vertex .. 7

6.(5) Head twice the length of the eye; as seen from the side widening toward the truncate apex; eye and pronotum widely separated ..... *Acinaca* Ball & Hartzell

Head distinctly less than twice the length of the eyes; as seen from the side, distinctly narrowing and roundingly truncate; eyes contiguous with pronotum *Aridia* Ball & Hartzell

7.(5) Fore and middle femora and tibiae broadly foliaceous, carinated ..... *Loxophora* Van Ruzee

Fore and middle femora and tibiae normal 8

8.(7) Lateral carinae of the frontal tablet uniting some distance below the apex of the head ..... *Ticida* Uhler

Lateral carinae of the frontal tablet converging but not uniting before joining the vertex . . *Timonidia* Ball & Hartzell

GENUS DESERTA Ball and Hartzell

Deserta Ball, E. D. and Hartzell, A., Ann. Ent. Soc. Amer., vol. 15, pp. 141-142, 1922. Genotype: *Orgamara bipunctata* Ball, by original designation.

ORIGINAL DESCRIPTION

"This genus resembles *Yucanda* and *Orgamara* since the head is produced into a definite snoutlike process. It differs by having the apex of this process beaked and curved downward instead of being truncate and rounded. Vertex with sharply carinate parallel sides until just before apex where the margins become elevated phlanges which converge to a triangular point. Genal area extended in front of eye as a lateral compartment conspicuously separated from the frons by a prominent carina, behind eye forming an oval callosity. Frons with conspicuous lateral intermediate carinae separating the central elevated tablet bearing a median carina down the entire length, from the two lateral depressed compartments in which occur numerous round pores. Pronotum collarlike, completely encircling mesonotum anteriorly and with a distinct central tablet set off by prominent lateral carinae; a median carina equally prominent. Prominent median and lateral carinae on mesonotum. Tegulae lacking. The elytra brachypterous, irregularly reticulate. Hind wings absent. Legs simple; hind tibiae with seven strong spines."

GENERAL MORPHOLOGY

The genus is a difficult genus to classify due to the fact that specific differences although numerous, are of smaller magnitude than in many taxonomic groups. Hence there are no obvious characters on which to base keys. Ball (1922) states that most of the species which he described have been beaten from species of *Artemisia* of the western states. The exception, known to date,

is *Deserta raptoria* Ball which was collected from rabbit brush (Chrysothamnus). This ecological information probably means that each species of *Deserta* has a different plant as a host. If these host plants are mostly of the same genus then the close similarity of the insect species is not too unexpected.

Each species of *Deserta* can only be identified by a combination of numerous small differences which are best followed by studying the following synoptic chart in combination with the accompanying illustrations.

For quick identification the length of the head process seems to be the best character for classification. Male specimens also are a little more readily identified because in addition to head process they show slight differences externally in the tenth or anal segment. A separate key for males has been made based on differences in this latter structure.

Genitalia for both sexes are described below. But due to the complexity of the male phallic structures, which seem to have a double-walled theca which hides most of the aedeagus, the small size of these genitalia and the difficulty of arranging dissected material of this type always in the same or a standard position, comparisons are not too reliable.

Chief variations in the male phallus are found in the curious, large, dorsal membranous lobes (protrusible glandlike structures) of the theca and also in the apices of the aedeagal hooks. The female genitalia are complex in that they show varying degrees of sclerotization interspersed with membranous areas. The size of the teeth of the dorsal sclerotized lobe of the first valvula seems to be the most useful character.

An attempt was made to use the number of lateral spines on the hind tibia as a specific character. For species identification it proved unsatisfactory as several species varied between six, seven, or eight on different specimens. In one case there were nine for one leg and six for the other leg of the specimen. Numerous cases occurred of this variability between the two legs of the same specimen. In generic identification, however, it may be useful to know that the spines vary from six to eight on each leg with the most frequently occurring number being seven.

Female Terminal Abdominal Segments and Genitalia. The eighth tergum is like the preceding terga. The eighth sternum is mostly membranous with a broad, extremely short, somewhat sclerotized median plate, the lateral edge of which forms a heavily sclerotized

slender curved arm attached to the anteromesal angle of each large first valvifer. These large bilobed valvifers occupy most of the sternal region but do not meet at midline; each is partially divided at base by a membranous wedge into two lobelike plates.

The ninth tergum is distinct and forms posteriorly a narrow ring which runs ventrad beneath the tenth segment.

The tenth segment forms a broad flaplike plate which extends over the dorsal margins of the third valvulae. The eleventh segment is tubular, fitting into a hollow area of the tenth segment and bearing an apical hollow closed process called the *anal stylus.*

The first valvula is broadly attached to the first valvifer and is bilobed, the ventral lobe being mostly membranous, the dorsal lobe strongly sclerotized and with the outer margins bearing six teethlike projections, the two apical ones large and the others diminishing in size toward the base. A lateral armlike extension or ramus of the first valvula extends from the anterolateral angle of the first valvula and articulates to the ninth tergum; ventrad it extends on to the dorsal lobe of the valvula for approximately half its length as a sclerotized grooved rod.

The second valvulae are two triangular lobes, united at base and deeply telescoped cephalad; the dorsal combined surfaces form a very broad, sclerotized, somewhat triangular plate which is extended forward at mid-line as a slender arm and whose lateral apices are articulated to the vertical barlike second valvifer; the combined ventral bases of the valves form a partially sclerotized rectangular broad plate lying under the triangular sclerotized dorsal plate. Dorsad the second valvifer bears the third valvulae and also gives off a small sclerotized extension which articulates to the ninth tergum just behind the articulation of the ramus of the eighth segment. Ventrad the second valvifer leads directly into the ramus of the second valvula (Bonhag and Wick, 1953) which appears as a sclerotized rod along the exposed lateral margin of the valvula for two thirds its length. This ramus of the 2nd valvula apparently moves on the concave surface of the ramus of the first valvula.

The third valvula is quadrangular in flattened position, posteriorly is deeply notched, thus separating a dorsal membranous lobe lying completely protected by the anal plate, from a ventral sclerotized lobe which partially conceals the first valvulae. The apical margin of the valve bears a cluster of prominent setae.

Male Terminal Abdominal Segments and Genitalia. The terminal segments of abdomen are strongly telescoped, especially

dorsally so that as viewed from the side only the posterior margin of the ninth segment shows as a somewhat triangular plate. When dissected out the ninth segment consists of a single sclerotized ring. Attached to the ninth segment posteroventrad are the large spoon-shaped freely movable gonostyli, each with a prominent recurved hook on the dorsal margin and another lateral hook near base. The tenth and eleventh segment form the proctiger (See Bonhag and Wick, 1953). The tenth segment is prominent, at base formed into a large tube, thus causing the eighth and ninth terga to be telescoped under the seventh, the ventral apical margin of the tube extended ventrad and caudad over the phallus as a flaplike plate (anal flap). The eleventh segment is a reduced ringlike segment attached by a conjunctiva to the caudal end of the upper margin of the tube. The eleventh segment bears a single posterior projection, the anal stylus.

Male Genitalia. Each gonostylus is attached by a conjunctiva to a slender, transverse, sclerotized bar, from the center of which arises a perpendicular heavily sclerotized rod (probably the fused gonocoxopodites); the dorsal terminus of the rod attaches firmly to the base of the aedeagus at the point where the ejaculatory duct extends into the aedeagus.

A complex phallic structure is protected dorsally and laterally by the enlarged proctiger and ventrad by the paired gonostyli. The aedeagus is greatly reduced and mostly hidden by a double-sleeved theca, with the outer sleeve shorter than the inner one so that the latter is exposed where it joins the aedeagus. The theca, probably formed as an extended fold of the conjunctiva of the ninth segment, is supported at its base by a sclerotized brace which is attached to the ninth segment. The apical two thirds of the dorsal outer sleeve wall of the theca consists of two pairs of membranous lobes, the outer pair being large and conspicuous, the inner pair smaller. In normal position these lobes collapse into accordion-pleatlike folds. When placed in certain fluids, such as caustic potash, followed by acetic acid they become first extended and then fold together again. The ventral surface of the outer thecal sleeve forms a partially sclerotized basal plate; in some species two well sclerotized bars form a track under each aedeagal hook and two median membranous, pointed lobes extend caudad. At base the aedeagus appears as a strongly, sclerotized tube and apically bears a pair of greatly, elongated sclerotized hooks, whose curved apices extend beyond the caudal margin of the theca.

KEY TO THE SPECIES OF THE GENUS DESERTA

(For both sexes)

1. From above head process in front of eye (e-e, plate II, diagram 1) approximately three times length of eye (d-d); from sideview process extended to a narrowed beaklike apex due to upper margin bending suddenly at apex of laterofrontal carina (x, plate I, diagram 1) and acutely meeting the slightly angled lower margin (y); part of frons in front of eye (e-e, plant II, diagram 9) longer than part behind (f-f) 2

   From above head process not over 2½ times length at eye; from side view distance from origin of bend to apex shorter, upper margin (except *bipunctata*) gradually rounding to apex; part of frons in front of eye equal to or shorter than part behind 3

2. Lateral margins of vertex flaring but not greatly elevated at apex; apical plate of head process from cephalic view pentagonal but distinctly wider than long; uniform gray color, slightly irrorate ..... *raptoria* (Ball) p. 209

   Lateral margins of vertex elevated and suddenly constricted at apex so lateral compartments of frons are distinct; apical plate of head process pentagonal but length and width equal; darker, fuscous dots more numerous, ... *fuscata* n. sp. p. 205

3.(1) From side view lower apical angle of head process produced into a rounded knob, the upper margin of process flared and abruptly bent ventrad ..... *bipunctata* (Ball) p. 204

   From side view lower margin of head process straight or almost so, apex not forming a beak or knob, upper margin not flared, gradually rounded to meet lower margin 4

4.(3) Part of frons in front of eye (e-e) shorter than part behind (f-f); apical plate of head process from cephalic view pentagonal, its vertical length greater than its width, ... *obscura* (Ball) p. 207

   Part of frons in front of eye equal to part behind; apical plate broader than long 5

5.(4) Laterofrontal carina and genal compartment in front of eyes conspicuous, vertex flared at apex obscuring frontal compartments; central tablet of frons occupying most of apical portion ..... *pinturensis* n. sp. p. 208

   Laterofrontal carina and genal compartment not conspicuous, lateral margins of vertex constricted anterior to eyes, narrowing to a pointed apex; central tablet of frons not distinctly widened at apex ..... *obesa* (Ball) p. 206

KEY TO THE SPECIES OF THE GENUS DESERTA

(Key to Males, based on external genitalia)

1. Anal flap with upper surface bulbous at base, greatly produced caudad; measured from dorsal view its length at a-a (plate III, diagram 20) more than twice the length of anal tube at b-b; lateral margin distinctly notched just before apex and extended ventrad as a distinct phalange, 2
Anal flap shorter, its length from a-a less than twice the length of anal tube at b-b; lateral margin at most only shallowly notched and slightly expanded ventrad 3

2.(1) Anal flap more bulbous at base; apical margin rounded, ninth sternum without dark patch ..... *pinturensis* n. sp. p. 208
Anal flap slightly bulbous; apical margin truncate, dark fuscous patch occupying center of 9th sternum, *bipunctata* (Ball) p. 204

3.(1) Anal flap shorter, its length less than 1½ times length of anal tube; apical margin of flap concave 4
Anal flap length over 1½ times the length of anal tube; apical margin rounded 5

4.(3) Anal flap with upper surface flat, neither bulbous nor concave; apical margins shallowly and broadly concave; lateral margins parallel-sided, and not expanded, *obesa* (Ball) p. 206
Anal flap with upper surface concave through middle; apical margin bilobed, lateral margins parallel, then converging before apex ..... *obscura* (Ball) p. 207

5.(3) Anal flap with upper surface flat, apex blunt, ventrad margin somewhat more deeply notched and expanded ventrad as in *bipunctata* ..... *fuscata* n. sp. p. 205
Anal flap with upper surface slightly concave at base, apex rounded, ventral margin not notched at side or expanded, *raptoria* (Ball) p. 209

The symbols used in table I require special explanation as follows:

EXPLANATION OF TABLE I

LINE 2. Species marked "—" have margins of vertex constricting slightly but without abruptly bending downward at apex, species marked "0" gradually constricting from eyes to apex; those marked "△" have the margins bulging outward between eyes, constricted through middle, then flaring broadly at tip.

LINE 3. Species marked "0" are only slightly elevated.

LINE 4. Species marked "—" have the anterior extremity of vertex pointed, exposing frons on either side.

LINE 5. Species marked "—" have the vertex less than one-half as wide as long at its mid-point.

LINE 6. The symbol "0" indicates that the suture and compartment is only moderately conspicuous; symbol "—" that the sutures are not elevated and prominent and the genal compartment does not even show.

TABLE I.—*Synopsis* * *of the Genus Deserta*

	raptoria	fuseata	obscura	pinturensis	obesa	bipunctata
1. Length of head process in front of eye (e–e, Plate II diagram), as compared to length of eye at d–d.	x3	x3	x2	x2½	x2½	x2½
2. Lateral margins of vertex parallel margined for entire length, then abruptly bent ventrad.	+	+	—	△	0	0
3. Lateral margins of vertex elevated at apex of head.	—	0	—	—	+	0
4. Anterior extremity of vertex broadly rounded not exposing much of frons below.	+	—	+	+	—	—
5. Width of vertex through the middle one-half its length extended in front of eye.	+	—	+	+	+	—
6. Latero frontal carinae elevated and genal compartments as viewed from above conspicuous.	0	—	0	+	0	0
7. Apical plate of head from cephalic view pentagonal but wider than long.	+	0	—	+	+	0?
8. Apical plate of head showing from above.	—	—	0	—	—	+
9. Lateral view of head showing ventral margin straight and apex not produced into knob or beak.	—	—	0	+	+	△
10. Shape of body hemispherical, length to tip of anal tube less than twice its length.	+	—	+	0	+	0
11. Part of frons in front of eye (e–e in diagram 9, Plate II) equal to part behind (f–f).	—	—	0	+	+	+
12. Central tablet of frons occupying most of apical portion with lateral compartments scarcely showing.	—	0	—	+	—	—
13. Lateral carinae of frons distinctly converging posteriorly.	+	—	+	+	+	+
14. Length of anal flap from dorsal view (a–a) longer than anal tube (b–b). (See diagram 20, Plate III).	—	—	—	+	—	+
15. Anal flap bulbous at base.	—	—	0	+	—	+
16. Apical margin of flap rounded.	+	+	—	+	0	+

* + Indicates agreement with statement at left; —, the opposite; 0, an intermediate condition.

LINE 7. Symbol "—" indicates longer than wide; symbol "0?" indicates mere trifle wider; symbol "0" indicates length and width equal.

LINE 9. Species marked "—" have the lower margin curved and apex of head produced beaklike; species marked "0" have the lower margin slightly angulate but not produced; species marked "△" have lower margin straight and apex distinctly produced as a knoblike process.

LINE 10. Symbol "—" indicates more slender body, its length twice its width; symbol "0" indicates body ovate, with length approximately one and three-fourths times its width.

LINE 11. Species marked "—" have the part of frons in front of eye distinctly longer than part behind; species marked "0" have the part in front of eye shorter than the part behind.

LINE 12. Symbol "0" indicates lateral carinae converging to a pointed apex with lateral compartments conspicuous, at tip each one equal to half the width of median compartment.

LINE 13. Symbol "—" indicates that the lateral carinae are parallel and central tablet before eyes is not so wide as in other species.

LINE 14. Symbol "—" indicates length of flap is equal to or slightly shorter than the tube.

LINE 15. Symbol "0" indicates flap is concave at base.

LINE 16. Symbol "—" indicates apical margins deeply indented; symbol "0" indicates margin broadly concave.

Deserta bipunctata (Ball)

Orgamara bipunctata. Ball, E. D. Proc. Biol. Soc. Washington, vol. 22: p. 199, 1909; Ball, E. D. and Hartzell, A. Ann. Ent. Soc. Amer., vol. 15, pp. 142-143, 1922.

Size: Length of female 6.5 mm, width, 2.6 mm.; length of male 6.25 mm., width 2.3 mm.

Color: This species is dull fuscous, irrorate with brown and has darker patches occurring on the wings. A large dark brown spot occupies the center of the ninth sternal plate.

In the original description Ball (1909) describes the species as having "a pair of round white spots just inside the apices of the abbreviate elytra and a pair of light stripes extending from these to the apex of the abdomen." In a revised description (1922) these markings were not mentioned. Perhaps less emphasis was placed on these light marks since the same pattern frequently occurs in most of the other species although in varying degrees of intensity. In *bipunctata* the markings are particularly conspicuous.

Structural Details: This species has a moderately long head process and the body distinctly irrorate. The proctiger of male is large with the anal flap (a-a) two and one-half times length of anal tube (b-b); the anal flap is bulbous at base, each lateral margin is greatly expanded caudad, and the apical margin is truncate, and deeply notched on each side. Other structural compari-

sons can be found in the synopsis chart, Table I, p. 203, and the illustrations on Plates I, II and III.

Types: Originally described from seven specimens, collected from St. George, Utah, by E. D. Ball, July 24, 1908. One male specimen from the syntype series is hereby designated lectotype and one female from the same series as lectoallotype. All types in the United States National Museum. Three homotypes, one male and two females, collected from Leeds, Utah, August 9, 1936, by R. H. Beamer in the Snow Entomological Museum.

Distribution: Leeds and St. George, Utah. Also recorded by Ball and Hartzell from Ravena, California, probably on *Artemisia tridentata.*

Deserta fuscata n. sp.

Size: Length of female 5.85 mm, width 2.2 mm.; length of male 6.3 mm., width 2.2 mm.

Color: General color much darker than other species, the female being darker than the male. Background yellowish-tan with greenish tinge in some areas. The entire body heavily irrorate with dark. The cells of the tegmina dark fuscous; in the female the mesal half of each tegmen darker than the lateral half. The female particularly resembles *bipunctata* by possessing a pair of conspicuous, elevated longitudinal cream-colored stripes, bordered mesad in each abdominal segment by a blackish-brown spot.

Structural Details: Resembling *D. raptoria* in size and form, somewhat longer and more slender with lateral margin of body at middle less rounding. Length and shape of head process similar to *raptoria*, narrowing to a raptorial beak, which is a trifle longer than in *fuscata.* Apical plate of head from cephalic view pentagonal, with length and width equal.

The anal flap of proctiger of male shorter than in *raptoria* or *bipunctata* with its length about one and one-half times the length of the tube; its ventral margin is flared and its caudal margin distinctly notched on each side.

For other differences consult the chart on p. 203 and the illustrations on Plates I, II, III and IV.

Genitalia: *Male*: The laterodorsal pair of membranous lobes of the theca are much larger than the mesal pair and both pairs are deeply pleated and capable of much expansion. The paired membranous apical lobes of the ventral thecal wall are prominent. The apices of the aedeagal hooks are bluntly pointed, sharply re-

curved and show a light colored bar and slight constriction at the base of the curved portion of the hook.

Female: The proportion of membranization and sclerotization of the valvulae is shown in the drawing on plate III. The dorsal lobe of the third valvula is more sclerotized than in *raptoria*, having several folds overhanging more membranous areas. On the dorsal lobe of the first valvula the second tooth from apex is smaller, the third tooth more slender and the sixth tooth larger than in *raptoria*.

Types: Described from holotype male, allotype female, eleven paratype males, and fourteen paratype females, Cajon Pass, California, August 6, 1936, collected by R. H. Beamer: additional paratypes identified as follows; one female paratype, Mojave, California, July 7, 1933, (R. H. Beamer); one female paratype, Monrovia, California, July 27, 1935, (R. H. Beamer); one female paratype, Los Angeles County, California, July, (Coquillett). These types are in the Snow Entomological Museum, University of Kansas.

Distribution: California.

Deserta obesa (Ball)

Orgamara obesa. Ball, E. D. Proc. Biol. Soc. Washington, Vol. 22, p. 199, 1909; Ball, E. D. and Hartzell, A. Ann. Ent. Soc. Amer., Vol. 15, pp. 142-143, 1922.

Size: Length of female 6 mm.; length of male 4.5 mm., width 1.95 mm.

Color: In the orginal description described by Ball as follows: "Pale straw, slightly washed with orange and sprinkled with smoky brown, giving the whole insect a dirty orange caste, Cephalic process pale, sparsely dotted with fuscous, about three pairs of heavier spots along the outer carinae just below the apex. Clypeus reddish orange. Pronotum and scutellum pale, sparsely dotted. Elytra with nervures pale straw, the cells smoky."

Structural Details: This species has a shorter head process than other species except *obscura*. From *obscura* it differs by the process being proportionately narrower. The proctiger of male is least developed in the species; length of anal flap is only one and one-fourth times the length of the anal tube, its dorsal surface is not bulbous or concave, sides are parallel and apex broadly concave.

Other structural details can be found in the synopsis chart, Table I, p. 203 and the illustrations on Plates I, II, and III.

Types: Originally described from three specimens from Parowan and American Fork, Utah, collected by E. D. Ball. One male

specimen from the syntype series, Parowan, Utah, July 21, 1908 is hereby designated lectotype. All types in the United States National Museum.

Distribution and Host Plant Records: Parowan and American Fork, Utah. Collected from sage brush in July and August (Ball and Hartzell, 1922).

Deserta obscura (Ball)

Orgamara obscura. Ball, E. D. Proc. Biol. Soc. Washington, Vol. 22, p. 199, 1909; Ball, E. D. and Hartzell, A. Ann. Ent. Soc. Amer. Vol. 15, pp. 142-143, 1922.

Size: Length of female 5.1 mm., width 2.5 mm.; length of male 4.8 mm, width 2.1 mm.

Color: General color yellowish gray. Described by Ball as being "white, finely sprinkled with dark points, giving the whole insect an ashy gray appearance. Front greenish, the clypeus rusty orange."

Structural Details: Head process short, part in front of eyes being only about twice length of the eye, stouter than in *obesa*. Proctiger of male less developed as in *obesa*, the anal flap only one and one-third times the length of the anal tube, its dorsal surface slightly concave instead of bulbous, the ventral margin scarcely expanded, the apical margin angulately concave and not notched at sides.

Other structural details can be found in the synopsis chart, Table I, p. 203 and the illustrations on Plates I, II, III and IV.

Genitalia: Male: The lateral membranous lobes of the dorsal thecal wall larger than in *raptoria* and proportionately larger than middle lobes. The sclerotized bars of the ventral thecal wall are roundingly pointed and the paired membranous ventral apical lobes are longer than in *raptoria*. The aedeagal hooks taper to a fine point and have sharp finely pointed serrate subapical margins.

Types: Described from eight specimens, collected by E. D. Ball, from Nampa, Idaho. These types are in the United States National Museum.

Two homotypes, collected at Somerville, Utah, July 5, 1931, by R. H. Beamer. These specimens are in the Snow Entomological Museum.

Distribution and Host Plants Records: Collected from sagebrush. Recorded by Ball and Hartzell from the following localities: Nampa, Idaho; Wells, Nevada; Marysvale and Chadburn's, Utah; Doyle and Chilcoot, California. Somerville, Utah, is now added to this list.

These authors make the statement that this species seems to be confined to the state of Nevada and a narrow fringe of adjoining states and only on the higher levels where sagebrush grows. They reported that nymphs and adults were collected at lower altitudes during July with adults all out by July 20th but that in the mountains nymphs were still present up to early August and adults up to the last of the month.

Deserta pinturensis n. sp.

ORIGINAL DESCRIPTION

Size: Length of female 7 mm., width 3.1 mm., length of male 7 mm., width 2.7 mm.

Color: General color straw yellow, sparsely irrorate with light brown, especially on vertex between eyes. Mesal half of each tegmen clouded with fuscous. No sharply contrasting spots or stripes present on abdomen. The conspicuous brown patch in center of 9th sternal plate found in *bipunctata, obesa,* and *obscura* is lacking in this species.

Structural Details: Resembling *D. bipunctata* but head process from above shorter and stouter, the part in front of eye being approximately two and one-fifth times the length of the eye; from side view lower margin of head process straight and apical angle not produced as in *bipunctata*; apical plate of process broader than long.

Proctiger of male long as in *bipunctata*, the anal flap about two and one-half times the length of the anal tube, strongly bulbous at base, ventral margin distinctly expanded and caudal margin roundingly pointed through middle and deeply notched on each side.

Genitalia: Male: The outer pair of lobes of the dorsal theeal wall are developed as long, tapering sacks which are capable of much expansion due to the deep accordion-pleatlike folds of their membranous walls and the helical twisting of their apices. The ventral theeal wall shows two pairs of membranous apical lobes instead of the usual one pair. The apices of the theeal hooks are drawn out into long, fine slightly recurved spines.

Female: The dorsal lobe of the third valvula is less membranous than in such species as *raptoria* and the ventral lobe is slightly more hirsute than in other species. The pattern of the teeth of the dorsal lobe of the first valvula shows the third tooth smaller than usual, thus making the third, fourth and fifth teeth approximately equal in size, and the sixth tooth only slightly smaller than these three.

Types: Described from holotype male, allotype female, seven male paratypes and eight female paratypes, all identified by the following data; Pintura, Utah, August 11, 1929, R. H. Beamer collector: additional paratypes identified as follows; one male paratype, Orderville, Utah, August 27, 1950, H. C. Severin, collector; one female paratype, Lone Pine, California, July 27, 1947, R. H. Beamer, collector. These types in Snow Entomological Museum, University of Kansas.

Deserta raptoria Ball

Deserta raptoria. Ball, E. D. Bull. Brooklyn Ent. Soc. vol. 32, p. 176, 1937.

Size: Length of female 6 mm., width 2.3 mm.; length of male 6.15 mm., width the same.

Color: A uniform, lighter gray species, sparsely irrorated, markings not so dark as in *fuscata*. Reticulations and apical portions of elytra light.

Structural Details: This species is distinguished from other species except *fuscata* by the longer, strongly hooked head process. From *fuscata* it is distinguished by its more ovate body shape, lighter color and apical head plate being wider than long.

The proctiger of male is moderately developed, the anal flap (at a-a) approximately 1¾ × the length of the anal tube (b-b), not bulbous at base, ventral margin only slightly flared, apical margin broadly rounded, indistinctly notched on each side.

For other structural features see chart I, page 203 and illustrations on plates I, II, III and IV.

Gentalia: *Male*: The two pairs of membranous lobes from dorsal wall of theca subequal, with the lateral lobes not greatly larger than middle lobes and also much smaller than in *obscura*. Sclerotized bars of the ventral thecal wall truncate instead of pointed, the paired membranous apical lobes prominent but shorter than in *obscura*. The aedeagal hooks roundingly truncate at apex, the apical fourth of each hook strongly bent back against the basal portion, the subapical serrations of outer margin blunt and inconspicuous.

Female: Variations in the degree of membranization and sclerotization of the three pairs of valves is best studied by an examination of drawings 1, 4, 6, 10, plate III. The chief differences between species seems to center around the teeth of the dorsal lobe of the first valvula. In this species the second tooth from apex is larger, the third tooth broader and the sixth tooth is more minute than in other species.

Types: Described from holotype female, allotype male and fourteen paratypes, collected by E. D. Ball, Tehachapi Pass, California, June 30, 1931. Ball failed to indicate, however, which female was the type. Therefore one female from the type series is herein designated as lectotype. One male, same data, is herein designated as lectoallotype. These types are in the United States National Museum. A large series of homotypes from Mint Canyon, California is in the Snow Entomological Museum, University of Kansas.

Distribution and Host Plant Records: California. Collected by Ball from a heavy stand of *Chrysothamnus* (Rabbit Bush).

Genus *Acinaca* Ball and Hartzell

Acinaca Ball, E. D. and Hartzell, A., Ann. Ent. Soc. of Amer., vol. 15, pp. 141-142, 1922.

Genotype: *Acinaca lurida* Ball and Hartzell, by original designation.

GENERIC DESCRIPTION

Closely resembling the palaearctic genus *Tigrahauda* Oshanin but apparently differing according to Ball and Hartzell by having the laterofrontal carina of the face curving abruptly upwards and ending in the dorsum, and vertex not furrowed, whereas in *Tigrahauda* the carina runs parallel to ventral margin of the cephalic process and vertex is furrowed.

Among nearctic genera *Acinaca* resembles *Yucanda* Ball and Hartzell in shape of head process as viewed from the side but is easily distinguished by the process being strongly compressed and much shorter than in *Yucanda*. From all other genera readily identifies by the scimitar shaped head process.

Body oval, head conspicuous, posterior region behind eyes considerably lenghtened and narrowed into a pseudo-neck, thus widely separating eye and pronotum. No callosity behind eye. Vertex narrow, median carina on basal half only, lateral margins carinate, erect, at base constricted, dilated between eyes, then beginning at eye angle converging to a pointed apex; a deep transverse bend across vertex just anterior to eye, which tilts the head process upward. Head process as seen from the side flat, length and width subequal, apex truncate, whole process strongly inclined upward. Central tablet of frons narrow, almost linear, tricarinate, carinae sharply delineated; lateral compartments of frons bearing large, round pores. Laterofrontal carina joining the vertex at a point one third the distance from apex of vertex to eye line. Apical plate

of head from cephalic view four-angled, widest near ventral surface where it is one-fourth as wide as its length.

Pronotum greatly narrowed anteriorly with middle third angularly produced forward, lateral thirds reduced to an extremely short collar, numerous round pores occurring on each side of a distinct median carian; no central tablet or lateral carinae present. Mesonotum small, an arcuated carina present following posterior line of pronotum, a short lateral carina on each side branching from this arc and a faint median carina indicated. Elytra brachyterous, finely and irregularly reticulated with veins scarcely raised. Pores on abdominal segments large and extending less than half way to median line. Femora and tibiae of the first and second pairs of legs somewhat compressed and edges slightly dilated; hind legs with three or four lateral spines on each tibia.

Acinaca lurida Ball and Hartzell

(Plates I and III)

Acinaca lurida. Ball, E. D. and Hartzell, A. Ann. Ent. Soc. Amer., vol. 15, p. 146, 1922.

Size: Length of female 3.5 to 3.8 mm., width 1.9 to 2.2 mm.; length of male 3.3 mm., width 1.9 mm.

Color: A strikingly bicolored species with all of head except clypeus and labium, as well as the central third of pronotum and the anterior third of mesonotum light greenish yellow, rest of body including tegmina uniformly reddish-brown or bright testaceous. Anterior and middle femora red-testaceous, striped with pale yellow lines; hind legs with tips of tibial spines dark. Central tablet of frons with two narrow dark brown stripes separated by the pale, elevated median carina. All facial carinae, except laterofrontals etched in dark brown, including the extreme apical margins of the head process.

Structural Details: A small, globose species; with prominent head and reduced thorax. Cephalic process extending in front of eye a distance equal to length of head. Dorsal plate of head process triangular, at base abruptly inclined dorsad at an acute angle to basal part of vertex. From side view head process appears as a broad scimitar-shaped blade with blunt truncate apex. Frons narrowed and central tablet between eyes strongly elevated, all carinae sharply accented. Clypeus with distinct median and lateral carinae.

Posterior margin of ninth segment of the male projected ventroposteriorly as an angulate armlike plate. Proctiger of male moder-

ately developed, the ventral extension of the tenth segment (anal flap) not much longer than dorsal length of the segment; upper surface of anal flap concave or hollowed almost to apex, its lateral margins not flared as in *Deserta* and its apical margin slightly notched through middle.

Genitalia: Male: Ventral wall of theca bilobed at apex, dorsal wall ending in two pairs of membranous lobes, which are capable of a certain amount of pleating and extension. Exposed portion of thecal hooks are bulbous at base, then suddenly are constricted just before apex into a slender recurved finger, and on each side bear a row of five minute short spines.

Female: The ventral lobe of first valvula is triangular, semi-membranous and fused with first valvifer; the dorsal lobe has its basal half which is bordered mesad by the rodlike ramus, folded under the sclerotized toothed portion, the three apical teeth broad, flat, approximately equal in size, the fourth tooth from apex much smaller and the basal tooth reduced to a minute spine.

The second valvulae are united at base as in other genera; the ramus of each valve is projected along the outer edge of the valve as a broad, heavily sclerotized bar while the basal half of the free mesal border appears as a membranous triangular area; the rest of the valve is moderately sclerotized.

The third valvula is quadrangular in flattened position, posteriorly is deeply notched, thus separating a dorsal fingerlike lobe from the broader rectangular ventrolateral lobe; the posterior third of the latter lobe is covered by prominent setae.

Types: Described from three pairs from Mojave, California, July 30, 1912, E. D. Ball, collector. These types in the National Museum, Washington, D. C. Two homotypes, male and female, compared by Ball with the types are in the Snow Entomological Museum. These specimens bear the following data; Prescott, Ariz. Aug. 7, 1932, R. H. Beamer collector. Also in the latter collection are two topotype females, bearing the data, Mojave, California, July 7, 1933, R. H. Beamer collector.

Distribution: Specimens have been collected from Arizona, California and New Mexico.

For this study specimens were on hand from Arizona as follows; Prescott, 5 females and 6 males, same data as homotypes above, from Prescott on July 29, 1933, 5 females and 7 males, two females from Miami, Aug. 6, 1944, one female from Indian Hot Springs,

Aug. 6, 1941, one female, Kingman, July 29, 1936, all specimens collected by R. H. Beamer.

From California specimens were on hand as follows: one male, Aug. 1, 1935 and one female Aug. 6, 1936, Cajon Pass, two males and three females July 18, 1940, Campo, R. H. Beamer collector; in addition Ball and Hartzell state that they studied specimens from Ravena, California. In New Mexico a large series of 15 males and 26 females was collected on July 22, 1936 from Silver City by R. H. Beamer.

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PLATE I

1. Lateral view of head process of *Deserta raptoria* Ball (paratype male).
2. Same view of *Deserta fuscata,* n. sp. (holotype male).
3. Same view of *Deserta obesa* (Ball), (male lectotype).
4. Same view of *Deserta pinturensis,* n. sp. (holotype male).
5. Same view of *Deserta obscura* (Ball), (homotype male).
6. Same view of *Deserta bipunctata* (Ball), (male lectotype).
7. Cephalic view of head process of *Deserta obscura* (Ball).
8. Same of *Deserta bipunctata* (Ball).
9. Same of *Deserta fuscata* n. sp.
10. Same of *Deserta obesa* (Ball).
11. Same of *Deserta raptoria* Ball.
12. Same of *Deserta pinturensis* n. sp.
13. Dorsal view of *Deserta bipunctata* (Ball).
14. Dorsal view of *Acinaca lurida* Ball and Hartzell.

14a. Ventral view of head of *Acinaca lurida* Ball and Hartzell.
14b. Lateral view of head of *Acinaca lurida* Ball and Hartzell.
14c. Dorsal view of head of *Acinaca lurida* Ball & Hartzell.
14d. Dorsal view of second valvulae of ovipositor of *Acinaca lurida* Ball & Hartzell.
14e. Flattened view of first valvula of ovipositor of *Acinaca lurida* Ball & Hartzell.
14f. Flattened view of third valvula of ovipositor of *Acinaca lurida* Ball & Hartzell.
14g. Dorsal flattened view of male proctiger of *Acinaca lurida* Ball & Hartzell.
14h. Foreleg of *Acinaca lurida* Ball & Hartzell.
14i. Cephalic view of head process of *Acinaca lurida* Ball & Hartzell.
14j. Ventral view of male genitalia of *Acinaca lurida* Ball & Hartzell.
14k. Lateral view of male genitalia of *Acinaca lurida* Ball & Hartzell.
14l. Lateral view of apical segments and male genitalia of *Acinaca lurida* Ball & Hartzell.

PLATE I

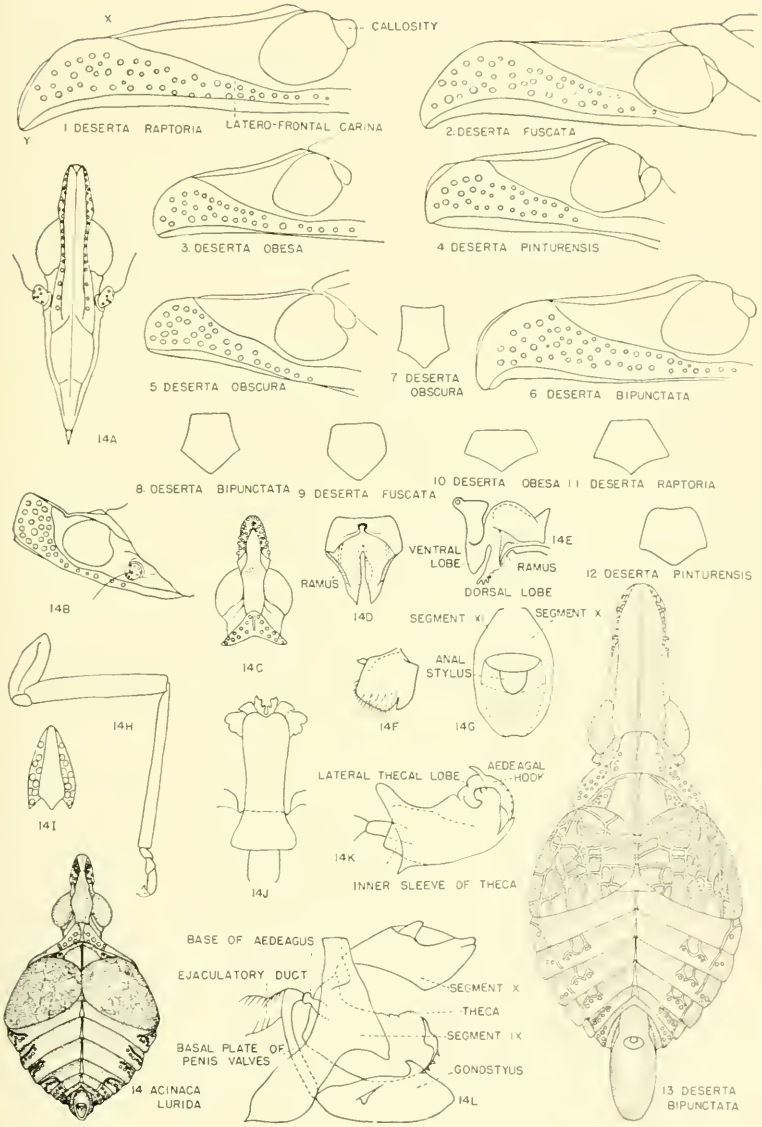

X
CALLOSITY
Y
1 DESERTA RAPTORIA
LATERO-FRONTAL CARINA
2. DESERTA FUSCATA
3. DESERTA OBESA
4 DESERTA PINTURENSIS
14A
5 DESERTA OBSCURA
7 DESERTA OBSCURA
6 DESERTA BIPUNCTATA
8. DESERTA BIPUNCTATA
9 DESERTA FUSCATA
10 DESERTA OBESA
11 DESERTA RAPTORIA
14B
14C
RAMUS
14D
VENTRAL LOBE
14E
RAMUS
DORSAL LOBE
12 DESERTA PINTURENSIS
SEGMENT XI
SEGMENT X
ANAL STYLUS
14F
14G
14H
14I
LATERAL THECAL LOBE
AEDEAGAL HOOK
14J
14K
INNER SLEEVE OF THECA
BASE OF AEDEAGUS
EJACULATORY DUCT
SEGMENT X
THECA
SEGMENT IX
BASAL PLATE OF PENIS VALVES
GONOSTYUS
14 ACINACA LURIDA
14L
13 DESERTA BIPUNCTATA

PLATE II

1. Dorsal view of head of *Deserta pinturensis*, n. sp. (holotype male).
2. Same view of *Deserta obesa* (Ball), (male lectotype).
3. Same view of *Deserta bipunctata* (Ball), (male lectotype).
4. Same view of *Deserta raptoria* Ball, (paratype male).
5. Same view of *Deserta obscura* (Ball), (homotype male).
6. Same view of *Deserta fuscata* n. sp. (holotype male).
7. Ventral view of frons of *Deserta obscura* (Ball).
8. Same view of *Deserta obesa* (Ball).
9. Same view of *Deserta raptoria* Ball.
10. Same view of *Deserta bipunctata* (Ball).
11. Same view of *Deserta fuscata* n. sp.
12. Same view of *Deserta pinturensis* n. sp.

PLATE II

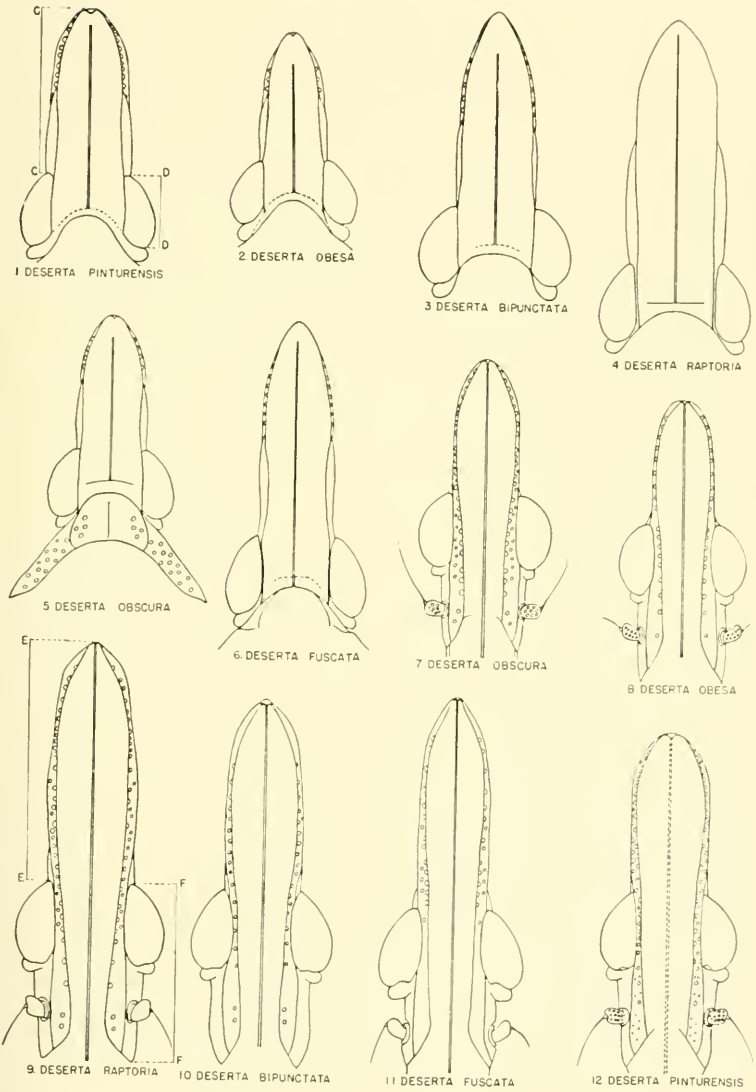

C
C
D
D
1 DESERTA PINTURENSIS
2 DESERTA OBESA
3 DESERTA BIPUNCTATA
4 DESERTA RAPTORIA
5 DESERTA OBSCURA
6. DESERTA FUSCATA
7 DESERTA OBSCURA
8 DESERTA OBESA
E
E
F
F
9. DESERTA RAPTORIA
10 DESERTA BIPUNCTATA
11 DESERTA FUSCATA
12 DESERTA PINTURENSIS

PLATE III

1. Lateral view of apical segments and female genitalia of *Deserta raptoria* Ball.
2. Ventral view of terminal abdominal segments and ovipositor of *Deserta raptoria* Ball.
3. Lateral view of terminal abdominal segments and ovipositor of *Acinaca lurida* B. and H.
4. Flattened view of third valvula of ovipositor of *Deserta raptoria* Ball.
5. Dorsal view of second valvulae of ovipositor of *Deserta pinturensis* n. sp.
6. Flattened view of first valvula of ovipositor of *Deserta raptoria* Ball.
7. Flattened view of third valvula of ovipositor of *Deserta fuscata* n. sp.
8. Flattened view of first valvula of *Deserta pinturensis* n. sp.
9. Dorsal view of second valvulae of *Deserta fuscata* n. sp.
10. Same view of *Deserta raptoria* Ball.
11. Flattened view of third valvula of ovipositor of *Deserta pinturensis.*
12. Dorsal flattened view of male proctiger of *Deserta fuscata* n. sp.
13. Lateral view of apical abdominal segments of the male of *Deserta fuscata* n. sp.
14. Flattened view of first valvula of ovipositor of *Deserta fuscata* n. sp.
15. Lateral view of apical abdominal segments of the male of *Deserta pinturensis* n. sp.
16. Dorsal view of male proctiger of *Deserta pinturensis* n. sp.
17. Lateral view of apical abdominal segments of the male of *Deserta obscura* (Ball).
18. Same view of *Deserta raptoria* Ball.
19. Same view of *Deserta bipunctata* (Ball).
20. Dorsal view of male proctiger of *Deserta obscura* (Ball).
21. Same view of *Deserta raptoria* Ball.
22. Lateral view of apical abdominal segments of the male of *Deserta obesa* (Ball).
23. Dorsal view of male proctiger of *Deserta obesa* (Ball).
24. Same view of *Deserta bipunctata* (Ball).

PLATE III

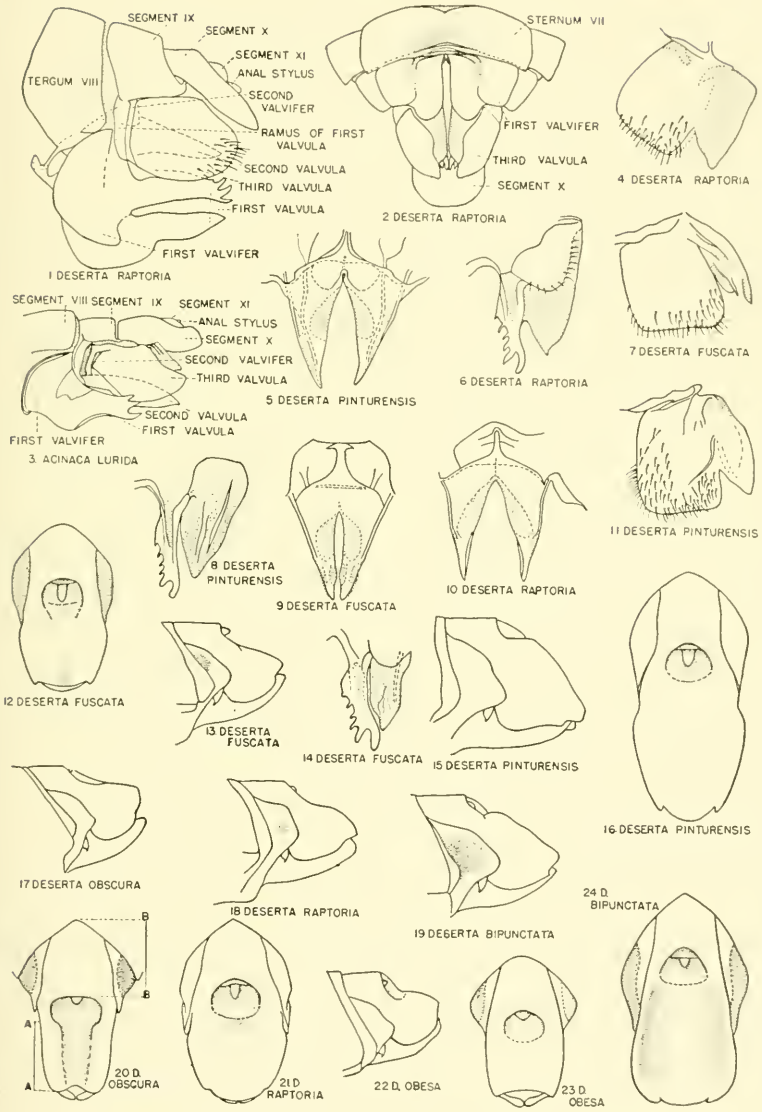
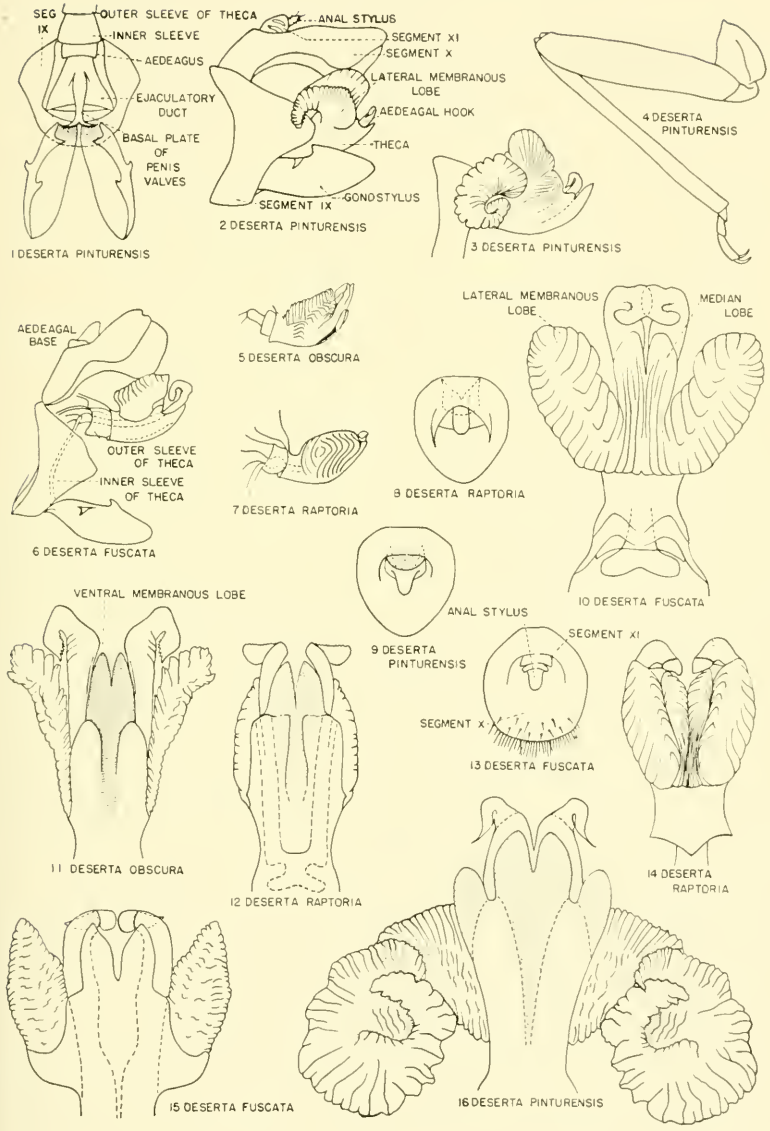

SEGMENT IX
SEGMENT X
SEGMENT XI
ANAL STYLUS
TERGUM VIII
SECOND VALVIFER
RAMUS OF FIRST VALVULA
SECOND VALVULA
THIRD VALVULA
FIRST VALVULA
FIRST VALVIFER
1 DESERTA RAPTORIA
STERNUM VII
FIRST VALVIFER
THIRD VALVULA
SEGMENT X
2 DESERTA RAPTORIA
4 DESERTA RAPTORIA
SEGMENT VIII
SEGMENT IX
SEGMENT XI
ANAL STYLUS
SEGMENT X
SECOND VALVIFER
THIRD VALVULA
SECOND VALVULA
FIRST VALVULA
FIRST VALVIFER
3 ACINACA LURIDA
5 DESERTA PINTURENSIS
6 DESERTA RAPTORIA
7 DESERTA FUSCATA
8 DESERTA PINTURENSIS
9 DESERTA FUSCATA
10 DESERTA RAPTORIA
11 DESERTA PINTURENSIS
12 DESERTA FUSCATA
13 DESERTA FUSCATA
14 DESERTA FUSCATA
15 DESERTA PINTURENSIS
16 DESERTA PINTURENSIS
17 DESERTA OBSCURA
18 DESERTA RAPTORIA
19 DESERTA BIPUNCTATA
24 D. BIPUNCTATA
B
B
A
A
20 D. OBSCURA
21 D. RAPTORIA
22 D. OBESA
23 D. OBESA

PLATE IV

1. Dorsal view of ninth segment and male genitalia which have been pulled forward and laid out flat of *Deserta pinturensis* n. sp.
2. Lateral view of apical segments and male genitalia of *Deserta pinturensis* n. sp.
3. Lateral view of male genitalia, showing membranous dorsal lobes of the theca distended, of *Deserta pinturensis* n. sp.
4. Foreleg of *Deserta pinturensis* n. sp.
5. Lateral view of male genitalia with dorsal lobes of theca collapsed of *Deserta obscura* (Ball).
6. Lateral view of apical segments and male genitalia of *Deserta fuscata* n. sp.
7. Lateral view of male genitalia of *Deserta raptoria* Ball.
8. Dorsal view of terminal abdominal segments of female of *Deserta raptoria* Ball.
9. Same view of *Deserta pinturensis* n. sp.
10. Dorsal view of phallus of *Deserta fuscata* n. sp.
11. Ventral view of phallus of *Deserta obscura* (Ball).
12. Same view of *Deserta raptoria* Ball.
13. Dorsal view of terminal abdominal segments of female of *Deserta fuscata* n. sp.
14. Dorsal view of phallus of *Deserta raptoria* Ball.
15. Ventral view of phallus of *Deserta fuscata* n. sp.
16. Same view of *Deserta pinturensis* n. sp.

PLATE IV


SEG IX
OUTER SLEEVE OF THECA
INNER SLEEVE
AEDEAGUS
EJACULATORY DUCT
BASAL PLATE OF PENIS VALVES
1 DESERTA PINTURENSIS
ANAL STYLUS
SEGMENT XI
SEGMENT X
LATERAL MEMBRANOUS LOBE
AEDEAGAL HOOK
THECA
GONOSTYLUS
SEGMENT IX
2 DESERTA PINTURENSIS
3 DESERTA PINTURENSIS
4 DESERTA PINTURENSIS
AEDEAGAL BASE
OUTER SLEEVE OF THECA
INNER SLEEVE OF THECA
6 DESERTA FUSCATA
5 DESERTA OBSCURA
7 DESERTA RAPTORIA
8 DESERTA RAPTORIA
LATERAL MEMBRANOUS LOBE
MEDIAN LOBE
10 DESERTA FUSCATA
ANAL STYLUS
9 DESERTA PINTURENSIS
SEGMENT XI
SEGMENT X
13 DESERTA FUSCATA
VENTRAL MEMBRANOUS LOBE
11 DESERTA OBSCURA
12 DESERTA RAPTORIA
14 DESERTA RAPTORIA
15 DESERTA FUSCATA
16 DESERTA PINTURENSIS

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Biological Studies and Taxonomic Notes on the Genus *Strongylogaster* Dahlbom.* (Hymenoptera: Tenthredinidae)

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INTRODUCTION

Observations on the biology of insects constitute an important source of information which is useful not only in establishing phylogenetic relationships but also in formulating methods of control for species that are economically important. Contributions to the knowledge of the bionomics of sawflies are of sporadic occurrence in the literature; but when such studies are aggregated and perused by a worker interested in the group, it is possible for him to draw conclusions which might otherwise be impossible without many years of accumulation of his own data. This paper constitutes a contribution to the knowledge of the bionomics of two species of North American sawflies with particular emphasis upon the developmental stages.

Although considerable work has been done on the classification of adult sawflies, the association of adults with their developmental stages as well as the association of sexes still remains as a field of investigation worthy of considerable attention. This situation is particularly applicable to the western species of sawflies, as the published information has been concerned largely with species found in the eastern United States. Yuasa (1922) estimated that more than eighty percent of the Nearctic species of sawflies are yet to be described in their developmental stages, and the situation has changed little since the appearance of his paper.

*Contribution No. 880 from the Department of Entomology, University of Kansas.

It is a generally accepted hypothesis that the sawflies represent the most generalized group of the order Hymenoptera. Because of this status the group has been an important center of interest to hymenopterists, and it may be found that observations on the bionomics of species within the group will contribute to the better understanding of the phylogeny of the Hymenoptera.

As a group the sawflies are most abundant in areas characterized by a temperate climate, but they are well represented by species showing a preference for a subtropical or tropical environment. For example, in the genus *Strongylogaster* from which two species are treated in this paper, approximately one sixth of the described species are indigenous to subtropical and tropical areas, the remainder being recorded only from temperate regions. With the advent of the use of synthetic organic insecticides in recent years, field testing has focused the attention of many economic entomologists upon the shortcomings of limited knowledge of the developmental stages of many common insects. It is often imperative that specific information regarding the life cycle, ecological preferences and physiological attributes of a pest be understood in order to direct effectively control measures. Thus many insect groups originally investigated through morphological characters of the adults alone are being restudied to supplement this information with biological data of all stages of development. In many instances a population of insects, which was believed originally to be comprised of a single species, subsequently has been found to have more than one constituent when physiological characteristics were investigated, a situation which often may be verified by detailed study of the differences in immature forms. There are many species of sawflies which are impossible to distinguish at the present time by morphological characters of the adults alone, but conspicuous differences may be found in morphological characters of immature forms, ecological preferences and physiological limitations.

Due to their rather common occurrence, immature stages of sawflies have interested naturalists for many years. Many references were made to various forms before the time of Linnaeus. It is probable that more studies would have been made were it not for the difficulty of rearing and the emphasis which was given by early workers to studies of adult insects only. Among the more noteworthy contributions to the literature dealing with immature forms of sawflies are the works of Dahlbom, Dyar, Cam-

eron, Konow, Middleton, MacGillivray, Lepeletier, Westwood and Yuasa.

Methods and materials: The problems facing an individual interested in the investigation of the biology of sawflies are exceedingly numerous. The most difficult problem encountered is due to a one year life cycle which is characteristic of the majority of species. Such a situation prevails in numerous other insect groups, to be sure, and may often consume more time than one year, but one can only envy those investigators who are able to keep continuous cultures going in all stages of development throughout the year.

Much of the rearing discussed in the following pages was conducted in the laboratory utilizing shell vials, and glass jars of various sizes as rearing chambers. Glass jars rather than screen cages were used in order to maintain humid conditions. Food materials were placed either in a cotton-plugged vial vase within the rearing chamber or else the base of the stem or leaf was wrapped in wet cotton before being placed in the chamber in order to preserve the material in a fresh condition for as long as possible. Rearing chambers which were used out of doors consisted of one inch and two inch glass tubes as pupation containers and cloth covered lamp chimneys as rearing chambers. Some one inch stender dishes and three inch petri dishes were also used as rearing chambers.

It was found expedient to use shell vials as rearing chambers for the first few instars of the *Strongylogaster* larvae. Later instars were transferred to larger containers with food material in a vase as described above. It was found advisable to use cotton tightly wrapped with cloth as plugs for the vials because last instar larvae escaped through simple cotton plugs. Attempts were made to rear *Strongylogaster* larvae to maturity in the laboratory by allowing the larvae to enter old fern twigs on the surface of a layer of soil in the rearing chamber jar. This method was unsuccessful primarily due to the lack of control of molds which evidently destroyed the larvae during their long periods of quiescence in the pupation cells.

Outdoor rearing chambers which consist of glass tubes one inch in diameter inserted into the ground to a depth of two and one-half inches served as rearing containers too, with one-half inch of tubing left projecting above the ground surface, and this capped with brass screen.

All specimens upon which descriptions are based are in the Snow Entomological Museum at the University of Kansas. For preservation of larvae some specimens were placed directly in KAAD solution and after twenty-four hours transferred for permanent storage into seventy-five percent ethyl alcohol. Other specimens were killed in alcohol after which they were immersed in boiling water for one quarter to one half a minute and following this treatment were returned to seventy percent ethyl alcohol for permanent storage. Many individual specimens were dissected and mounted in balsam on glass slides. Clearing and, in some cases, staining of slide mounted material was found advisable. Adult specimens were mounted on pins or preserved in alcohol, the latter specimens being used for slide mounts.

The terminology utilized in descriptions is that followed by Yuasa (1922) and Ross (1937), and the system of classification proposed by Ross (1937) has been adopted for use in this paper.

TAXONOMY

The systems of arrangement of the higher categories of sawflies are almost as numerous as the authors working with the group. Perhaps the first important comprehensive treatment of the group was made by Konow (1905), the essentials of his arrangement being that adopted by Ross (1937) and subsequently by the writer for the purposes of this paper. In 1898, Ashmead developed a classification based upon wing venation and relative body proportions. MacGillivray, in 1908, after an exhaustive study of wing structure proposed a classification based upon this character alone. Rohwer (1911) followed Konow's groupings fairly closely. Enslin (1911), although emphatic in his denunciation of Konow's system, did not refute the most important concepts. A summary of the subject has been fairly well covered by Yuasa (1922) and Ross (1937). It might be appropriate, however, to review the status of the major categories so that the position of the species included in this paper may be clarified.

The order Hymenoptera is clearly separable into two distinct suborders, the Symphyta and the Apocrita, based largely upon the manner in which the abdomen joins the thorax. These two groups are identical in definition to the Chalastogastra and Clistogastra, names which are used by some authors. Ross (1937) recognized two definite series within the suborder Symphyta which he calls the Strophandria and the Orthandria, the distinction being the rotation of the male genitalia 180° on the median axis before eclosion

and supporting characters of wing venation in the Strophandria. He places the single superfamily Tenthredinoidea in the Strophandria series, with the Siricoidea, Megalodentoidea and Cephoidea in the Orthandria series.

The superfamily Tenthredinoidea is segregated into twelve families on characters of the antennae, spurs of front tibiae and thoracic structure. The largest of these families is the Tenthredinidae which is separated into ten subfamilies. It is in the division of this family into units that the greatest divergence of opinion occurs among workers with the group. Among the more recent studies is the exhaustive work of H. H. Ross (1937). His study led him to conclude that the hypothetical ancestor for the family had a prepectus, bidentate mandibles, simple antennae, proximal anal cell of anterior wings contracted in the middle and separated from the distal anal cell by a crossvein and the media of the front wings joining the radius at the fork of the radial sector.

Careful consideration of these characters shows that the subfamily Selandriinae approaches the primitive condition more closely than any other group. Ross recognized six genera in the nearctic assemblage of Selandriinae, including the genus *Strongylogaster*. Adults are separated from other members of the subfamily on the nature of the prepectus. Two species belonging to this genus are treated at length in this paper, and these represent a very primitive condition. The larvae of species of *Strongylogaster* are medium to large in size, finely but distinctly annulate, green in color with various characteristic brownish markings sometimes occurring on the head capsule and pleura. Thoracic legs are well developed and normal in form. Uropods are setiferous and occur on abdominal segments two to eight inclusive, and postpedes are present on the tenth abdominal segment. Specific characters used in larval identification include pigmentation of the head capsule, number and arrangement of setae on the clypeus, labrum, palpi, mandibles, pleura and uropods, antennal coloration and structure and comparative size of thoracic leg segments.

There follows a report of observations made on two species of *Strongylogaster*.

Strongylogaster tibialis Cresson

Strongylogaster tibialis Cresson, 1880, Trans. American Ent. Soc., vol. 8, pp. 19-20.

Female: Shiny black. Body covered with dense pile of short hairs, less conspicuous on dorsum of abdomen. Length 7.5 mm. Alar expanse 18 mm. Wings hyaline; nervures brown to black.

Head. Shiny black with dense covering of short hairs. Antennae filiform; second segment as long as broad; remaining segments decreasing in length from third to ninth inclusive. Clypeus honey-colored with proximal margin and narrow distal margin black, angularly emarginate, clothed with long, pale hairs. Labrum rounded truncate, honey-colored, densely pilose. Palpi amber, faintly infuscate. Mandibles black at base, toothed margin reddish-brown, pilose, bidentate. Ocelli reddish, ocellar area a triangular elevation, caudal margin of anterior ocellus with Y-shaped furrow which joins transverse post ocellar furrow connecting caudal margins of posterior ocelli. Cervical sclerites shiny black. *Thorax:* Tergum of prothorax constricted forming narrow black collar on meson, dorsolateral angular expansions honey-colored, posteroventral angles shiny black. Tegulae and cenchri honey yellow; remainder of thorax shiny black, densely pilose. Prepectus a raised shoulder, separated from episternum by a deep furrow. *Abdomen:* Shiny black except narrow caudal margins of tergites two through nine inclusive, pleurites and median and caudal portions of sternites which are honey-colored. Pile short on dorsum, longer on pleura and venter. Sheath shiny black, angulate, projecting slightly beyond cerci. *Legs:* Black, except tips of femora, basal third of hind tibiae, front and middle tibiae and tarsi which are amber; tarsi with slight infuscation. Tarsal claws bifid, inner tooth short. *Wings:* Hyaline with principal nervures and stigma of front wings dark brown or black, the remaining nervures amber. Anal crossvein perpendicular. Hind wings with two middle cells.

Male: Length 6.5 mm. Alar expanse 13.5 mm. General description similar in most characters to female; entire venter of abdomen and all leg segments except hind tibiae and tarsi honey colored.

There is very little variation among individuals of this species, the pigmentation of the legs being the only character noted which shows any appreciable variation.

The above descriptions were made from specimens now deposited in the Snow Entomological Museum, University of Kansas. The holotype female, from Nevada, is in the collection of the Academy of Natural Sciences of Philadelphia.

A study of the biology of this species was initiated by the present author in the spring of 1947 and observations made during this study are presented in the discussion which follows.

DISTRIBUTION

Specimens examined by the writer have been taken in the following localities: WASHINGTON: Forks (July), *Clallam Co.* OREGON: Oney (June). CALIFORNIA: Mill Valley (Feb., Mar.) and Lagunitas (Mar.) *Marin Co.; San Francisco Co.* (Apr.), (no specific locality indicated); Pescadero (Apr.). *San Mateo Co.;* Point Richmond (Apr.), *Contra Costa Co.;* Berkeley (Mar., Apr., May) and Oakland Hills (Apr., May, June), *Alameda Co.;* Carmel (Feb., Mar., Apr.) and Sequel Creek (May), *Santa Cruz Co.;* Lake Tahoe (June) and Glen Alpine Creek (July), *Eldorado Co.;* Yosemite (May, July), *Merced Co.;* and Giant Forest (July), *Tulare Co.*

It is quite probable that this species is distributed along the entire Pacific Coast from British Columbia to San Diego, as no natural barriers to its migration occur in this area. The host plant, *Pteridium aquilinum*, has a continuous distribution throughout this region, and it seems logical to surmise that the occurrence of the species would be limited only by the arid, host free areas east of the coastal ranges of southern California, Sierra Nevada mountains of central and northern California and Cascades of Oregon and Washington. Cameron identified a specimen in his collection taken at Volcán de Chiriquí, Panamá, as this species. Since his specimen was not compared with the type, the identification may have been incorrect.

This species has been taken at sea level and elevations in the neighborhood of 5000 feet, occurring at many intermediate levels. Specimens taken at high elevations as well as those collected in Oregon and Washington, were obtained later in the spring than specimens collected from the central coastal region of California. This, of course, is the expected situation, indicating a later emergence of adults in areas of higher latitude or altitude.

BEHAVIOR OF ADULTS

This species, in common with most sawflies, is a very poor flier. Both sexes, when disturbed from a resting position on a leaf, frequently collide with vegetation while trying to escape. Their flight is erratic and because of this ineptness, alighting becomes a hit-or-miss proposition. The outstretched legs snag the vegetation as the insect flies over it and a crude landing is made which at times somersaults the individual, but more often the insect appears to throw itself upon the leaf or branch. Immediately after alighting the sawflies are very easy to catch by hand as they are not sufficiently oriented to take flight effectively.

The males spend a great deal of time in the vicinity of the host plants, making frequent, short, circular flights around a favored fern frond and returning to alight on the tip where they remain for a period, later repeating the performance. There appears to be a definite selection of a specific fern frond for a resting station from which short flights are made. While resting on the tip of a frond they are very alert to the flight of other insects, and it is quite possible that the females are thus spotted. The antennae are almost continuously in motion with a vibrating or quivering appearance. The front legs are extended, elevating the anterior portion of the body. Males are easily distinguished from females in the field by their smaller size and the narrow, paler abdomen.

Females spend much of their time on the host plant searching for oviposition sites. They walk down the main stalk of the frond after alighting on the tip, frequently proceeding as far down as two inches above the ground level. The frond is then reascended with some searching along lateral branches. Individuals have been observed for as long as thirty minutes during which time they crawled up and down a single frond searching along its main stem and lateral branches for a place suitable for oviposition. Flight is usually launched from the tip of the frond, although at times the sawfly will take wing from the upper surface of a branchlet.

When a satisfactory spot is found on the stem, the female prepares for ovipositing by facing downward. The abdomen is then humped so that the saw penetrates the epidermal tissues of the stem at or near a right angle. This position is maintained, with slight movements of the abdomen for about one minute. The abdomen is then flattened out against the stem with the hind legs often extended stiffly in a position at right angles to the body and not grasping the stem, and with the abdomen thus appressed to the stem there is a visible quivering for a ten second interval during actual egg deposition. Immediately after laying the egg the insect renews its search for another oviposition site. During much of the searching the females carry the abdomen in an arched position typical of the attitude assumed for the initial thrust described above. Frequently an incision is started but abandoned before egg laying is completed.

There appears to be a definite preference shown for depositing eggs in grooves of the most succulent portions of the stems and branches, as more than eighty percent of the eggs seen were so located.

The maximum number of eggs laid by one captive female during a twenty-four hour period was ten, the maximum number laid by a single female being twenty. This latter number was deposited by an individual in the following sequence: eight during the second twenty-four hours of captivity, nine during the following twenty-four hours, and three during the ensuing twenty-four hours. It might be stated here that during the first twenty-four hour period of captivity of this particular female, the rearing chamber was furnished with a vase containing two species of ferns, neither of which was the known host species. No oviposition was attempted on these ferns.

Most captive females deposited eggs if supplied with suitable material. On many occasions males and females were caged together but copulation was never observed. Captive insects did not at any time exhibit any antagonism toward one another. This fact was also observed in the field where two females would frequently encounter each other while walking along the fern stems searching for oviposition sites. On such occasions they merely bypassed without abnormal behavior or one or both would reverse its direction of progress.

Although feeding by the adults was never observed in the field, they often were observed to feed on sap exuding from fronds of *P. aquilinum* which were kept in vases in the rearing chambers. They also fed upon honey water applied in droplets to the sides of the chamber. Males have been kept alive for five days and females for seven days. Cause of death could not be determined in any instance. Both sexes when captured in a net or taken in hand habitually feign death by drawing the legs to positions closely appressed to the body and curling the abdomen inward so that the tip almost touches the thorax. This pretense of death is often maintained for a minute or more following their original disturbance.

LIFE HISTORY

This species, in common with most sawflies, has a one year life cycle. Adults emerge in April and early May in the San Francisco Bay region of California at which time the eggs are laid. Larvae have usually disappeared by early June and remain in the pupation cells in rotten wood until the following spring.

Egg stage: Eggs are deposited singly and in a random distribution on the tender, succulent stalks and bases of the branches of the host plant. They are inserted beneath the thin, hairy,

epidermal layer of the plant which serves as a protective covering for the egg. The insertion is not made into the tissues underlying the epidermis, and the egg displaces the epidermis causing it to stretch outward over the egg making it clearly visible as a raised object on the smooth stem surface. The entire egg is not covered by the parchmentlike epidermis, one end being exposed where the incision slit is made. Occasionally, due to faulty insertion by the female, eggs are entirely exposed with crumpled epidermal tissue of the fern clustered at the uppermost end of the egg. Oviposition is conducted ordinarily so that the egg is in a position parallel to the stem or branchlet. When deposition occurs at the thickened area of juncture of a lateral branch with the main stem of the frond, slight deviations from the parallel may be noted. Eggs are inserted only on the thickened portions of the frond, rarely being placed on stems less than one eighth of an inch in diameter. More than one hundred eggs have been seen in the field by the writer, and none were placed on the frond lower than two inches above the ground level.

When first laid, eggs are glistening pale yellow, oval in shape, averaging 1.1 mm. long and 0.5 mm. in greatest diameter. As the embryo grows the egg case stretches, increasing in all dimensions. Twenty-four hours after deposition the color is darker yellow with an oval-shaped opacity near the center and slightly larger at the caudal end. After forty-eight hours small brown specks representing the eye spots become visible at the anterior end of the egg. Color at this time is a yellow-orange. Seventy-two hours after deposition the egg is about 1.5 mm. long and 0.6 mm. in greatest diameter. Eye spots are clearly visible as black dots. Mouth parts appear brownish and the alimentary tract appears as an opaque area more definite in outline toward the posterior end. Movement of the embryo within the egg case may be noticeable at this time, particularly evidenced by a rotating motion of the anterior part of the body with the eye spots rolling from side to side. There is also a frequent withdrawing of the anterior end of the embryo from its normally appressed position to the egg case. Hatching occurs ninety-six hours after deposition, the larva emerging from a dorsal, longitudinal split which extends from the anterior end half the length of the egg.

The above incubation period is typical of specimens reared in the laboratory where the temperature remains fairly constant near 72° F. In the field the incubation period is of course variable,

depending upon prevailing temperatures. Eight days from egg deposition to hatching is the longest interval observed by the writer in the field.

Larva: First instar: Upon emergence from the egg the larva is very pale yellowish-white, almost transparent with the head capsule appearing large for the body. The body tapers caudad. Length 1.8 mm.; width of head capsule 0.35 mm. Ocellarae and ocularia black; mouth parts brownish.

Second instar: Length 4.0 mm.; width of head capsule 0.5 mm. Body almost transparent; blood giving green color to dorsum. Head capsule opaque white with small, fuscous, V-shaped area on dorsum of vertex and another fuscous masklike patch on front extending over distance between ocularia. Tibiae and tarsi of thoracic legs faintly fuscous.

Third instar: Length 9.0 mm.; width of head capsule 1.0 mm. Body green, paler ventrad; median, dorsal, longitudinal band darker green, the color being imparted by contents of the dorsal vessel. Head capsule opaque white, the infuscate mask of second instar not present, middorsal, dark area on vertex present. Tibiae and tarsi of thoracic legs fuscous.

Fourth instar: Length 11.5 mm.; width of head capsule 1.5 mm. Color same as previous instar with body slighly darker green. Head capsule opaque white or faintly amber with narrow, fuscous, middorsal line on vertex.

Fifth instar: Length 17.0 mm.; width of head capsule 1.9 mm. Color same as previous instar with head capsule opaque white with greenish, amber or faintly fuscous tinge and without median-dorsal, fuscous line on vertex. In the late active phase of this instar, just prior to excavating the pupal chamber, the body becomes reddish in color, particularly in the abdominal region.

Molting of all instars is accomplished after a dorsal, longitudinal splitting of the head capsule and thorax. The head splits along the epicranial stem and the larva pulls out of the exuvia by lifting the head upwards. Exuviae are commonly seen on the host plants. The caudal portion of the exuvia is cemented in place, prior to the anterior splitting, by extruding the viscous terminal portions of the alimentary tract. The larva, after pulling its head free from the old integument, merely crawls out of its skin, the entire process being completed in a very short time. A detailed description of the fifth instar larva follows.

Head subglobose, opaque white with a faint greenish tinge. An-

tennae prominent, five-segmented, broadly conical, with segments two through five inclusive black; first segment and narrow distal margin of second, third and fourth white; all segments with irregularly spaced sensory pits. Antacoriae large, with diameter equal to diameter of ocularia. Ocellarae shiny black, diameter approximately one half the diameter of ocularia, situated slightly anterodorsad of center of ocularia and bulging somewhat. Clypeus truncate with six strong setae. Labrum rounded truncate with shallow, median indentation distally, and with eight prominent setae. Maxilla with a five jointed palpus, the distal margin of fourth segment armed with six or seven stout, truncate bristles; one stout bristle on lateral margin of first, second and third segments, and two smaller bristles on fifth segment; apical segment without setae; galea flattened, curved inward to a rather abrupt point, the anterior margin with numerous small pits; lacinia flattened, margin with eight or nine broad spines. Labial palpi with three segments. Labium rounded truncate, bearing broad spines. Mandibles brown, quadridentate; edges of teeth serrate.

Prothorax with conspicuous, dark brown, winged spiracles, the spiracles absent on mesothorax and metathorax. Thoracic legs strong and prominent and normal in form, five-segmented; coxa nearly as broad as long; femur with apical lobe; tibia cylindrical; tarsal claw without teeth.

Abdomen elongate, tapering caudad. Uropods on segments two through eight inclusive and ten. Spiracles winged, located on segments one through eight inclusive; main trunk of trachea connecting spiracles visible as a white, threadlike line situated midlaterally. Abdominal segments seven-annulate with sparse and inconspicuous setae on annulations two, four and seven. Spiracular opening on second annulet. Small cylindrical glandubae sparsely distributed, being present only on setiferous annulets and most abundant on lateral folds immediately above uropods. All uropods armed with approximately twenty-two pale and inconspicuous setae.

The larvae, although normally colored green, fade to white in alcohol. Glandubae were not observed in living specimens as high magnification is required in order that they be seen. It is quite possible that they are retractile and that they are extruded when the larvae are killed in boiling water. They are present on all segments of the body with exception of the head capsule, and are more numerous on the abdomen than on the thorax.

Behavior of larva: Immediately after emerging from the egg the

young larva migrates upward on the fern frond until the small, curled tip of tender new growth is reached. Protection is sought within these curls of branchlets, the larva positioning itself usually upon the hairy under side of a leaflet within the coil. Here feeding begins, the larva remaining in or near the curl of tender tip growth until the fourth instar. When the fourth instar is reached, larvae may be found on exposed branchlets, reposing on either the upper or lower surfaces of the leaflets. It is in this and the succeeding instar that the greatest damage is inflicted upon the plants, as the larger larvae are voracious feeders.

In all instars the larvae, when disturbed vigorously wave the abdomen back and forth, throwing it from side to side and up over the thorax, while maintaining a grasp on the plant with the claws of the thoracic legs. It is possible that the glandubae function on such occasions by emitting substances repellant to natural enemies, but the writer has not been able to detect any peculiar odor or see any abnormal secretion at such times. Larvae in late instars frequently drop to the ground when disturbed, but in the first three instars it is extremely difficult to force them to lose their grasp on the host plant.

After the ultimate stage is entered the larva feeds voraciously for a few days and then becomes quite ambulatory, the first move being to descend from the fern frond. On the ground a search begins for a piece of dead wood suitable for penetration and construction of a pupal chamber. If not furnished with such material, larvae in captivity will wander around in the rearing chamber until death occurs. When a suitable piece of dead wood is found the larva immediately begins excavating a tubular cavity. The cavity is entered and plugged with frass, sealing the larva inside a tight-fitting chamber. This entire process is often completed in as little as three hours. For the remainder of its life as a larva it remains fairly quiet, at times moving slightly. Thoracic legs are pulled inward and are held close against the body. The body becomes shortened in length and somewhat shriveled in appearance. Larvae removed from the pupal chamber immediately after the frass plug is constructed have in every instance failed to construct another chamber. Often larvae make several beginnings at excavating a chamber before finally succeeding, the abandoned excavations being at almost all stages of completion. They have never been seen to abandon a chamber once the frass plug is completed. The cell proper is just large enough to accommodate the larva, being ap-

proximately 13 mm. long and 3 mm. in diameter. The frass plug varies in length from 5 to 10 mm. Old, dead fern stems from the previous season's growth which usually abound in areas where the larvae develop are frequently entered. Such stems are often penetrated two or three inches before the plug is constructed, and on some occasions when this material was used in rearing chambers more than one larvae entered the same end of the stem forming pupation cells in line, sealed off from adjacent cells by frass plugs.

Larvae remain green in color and shortened in length as well as somewhat shriveled in appearance in the chamber until early spring at which time metamorphosis to the pupal stage occurs. Because of the prolonged prepupal period, the larvae are very susceptible to attack by molds which frequently account for their death. Much difficulty has been encountered by the writer in rearing this species because of this fact. The most advisable method of handling larvae when they reach maturity appears to be the use of aseptic techniques, confining the larvae in sterile vials plugged with sterile cotton and with a piece of clean cork for construction of the pupal chamber.

Pupa: The pupal stadium is quite brief and its appearance is that of the typical exarate configuration.

Summary of life cycles: The eggs which are inserted on succulent stems of the host plant, *Pteridium aquilinum,* hatch in from four to eight days. The first instar larva which feeds on the tender apex of the frond lasts from two to four days. Larvae remain in the second instar for two to three days, continuing feeding under the protection of curled leaves at tips of the stems of the host plant. Duration of the third instar is one to three days. The fourth instar endures a four to seven day period. The fifth instar, which is the ultimate stage, is divisible into three distinct phases, the first being a phase of voracious feeding, the second a phase of searching for a pupation site and excavating the pupation cell and the third a phase of quiescence. The feeding phase lasts four or five days followed by a brief period of boring into dead wood for construction of the pupal chamber where the larva becomes quiescent for a period of about ten months. The pupal stage is of short duration, lasting from ten to fourteen days, after which the sawfly emerges as the winged adult. Thus the insect normally is in the egg for one week, an active larva for two to five weeks, a quiescent larva for about ten months, a pupa for two weeks and an adult for two or three weeks.

HOST PLANTS

Several species of ferns were placed in rearing chambers containing adult insects to test the selection of a host for oviposition and feeding. Although the sawflies thus confined were observed to feed upon plant juices exuding from breaks in the epidermis of many of the ferns, no attempts were made by the females to oviposit on any plant but the recognized host, *P. aquilinum*. Larvae were also confined in rearing chambers provided with various species of ferns. In all cases, they starved to death without even sampling the material, unless the known host was included.

Although a limited number of plants was utilized in this survey for possible hosts, it seems appropriate to conclude that this sawfly is confined to a single host.

NATURAL ENEMIES

More than one hundred larvae, taken from the field when nearly mature, failed to reveal any parasitism by other insects. It has not been in the writer's experience actually to witness the attack upon larvae or adults in the field by insect or arachnid predators or birds, although some such natural enemies no doubt exist. Old fern fronds have been taken which contained dead larvae in their pupation chambers, all indications pointing to the fact that their demise was caused by fungus attack. Diseases of neither adults nor larvae have thus far been seen.

ECONOMIC IMPORTANCE

Larvae of this species may at times become very destructive to ornamental plantings of the host plant. Bracken fern is used rather extensively in the San Francisco Bay region in landscape planning of rock gardens and hillside terrace gardens. These are often subject to the attack of this sawfly. The writer has seen large beds of such plantings completely denuded of foliage with only the skeletons of branches remaining after the ravages of the sawfly larvae. A simple inspection of the damaged plants often fails to reveal the culprits because the protective coloring of the larvae as well as the habit of the older larvae of dropping to the ground when disturbed which makes them difficult to see. Their presence may be rather easily verified, however, by the occurrence of whitish exuviae on the damaged branchlets. The injury to the fern plants is often blamed on slugs and snails, and much bait for these pests has been distributed by home owners in attempts to rid the ferns of the defoliator.

CONTROL

S. tibialis is easily controlled with certain sprays or dusts. Rotenone used at two pounds of 4.5 percent material per one hundred gallons of water will kill larvae effectively. Basic lead arsenate sprays at two pounds per one hundred gallons of water are also effective. DDT dusts and sprays are not effective even with spray applications as high as one pound of actual material per one hundred gallons of water.

Strongylogaster distans Norton

Strongylogaster distans Norton, 1868, Trans. American Ent. Soc., vol. 2, p. 220.

Female: Length 9.0 mm. Alar expanse 18.5 mm. Head, thorax and abdomen except tergites of third through ninth inclusive which are dark amber, black. Entire body clothed with dense pile. Wings hyaline, minutely but densely setiferous; nervures black to brown; stigma brown. *Head:* Black, densely pilose, minutely and uniformly punctate. Antennae stout, filiform; segments decreasing in length from third to ninth; terminal segment bluntly rounded; last seven segments densely clothed with short, stiff, black bristles; hairs on first two segments long; second segment as broad as long; first, one and one-half times as long as broad. Ocelli reddish; channels at their sides not reaching back of head. Eyes in anterior aspect slightly converging below, separated by a distance greater than their height. Clypeus black, emarginate, densely covered with long hairs. Labrum rounded truncate, amber-colored, with long hairs, nearly concealed by clypeus. Mandibles black, densely pilose, bidentate. Palpi pale, slightly fuscous, hairy. Cervical sclerites shiny black; ventromesal portion V-shaped, not meeting on meson. *Thorax:* Black, shining, densely clothed with sericeous pile; prepectus separated from episternum by a furrow. Tegulae, auxilliary sclerites and pronotum pale; anepimeron and katepimeron black; cenchri pale, distinct; post tergite shiny black. *Abdomen:* Broad, robust, the last three segments tapering to tip, dark honey-colored; tergites of first two segments black; first tergite divided forming narrow inverted V on meson; tergites three to nine marked with black patches medially in triangular pattern pointing caudad but with posterior margins of tergites always pale; venter honey-colored with lateral areas of sternites black forming two dark longitudinal bands on the venter. Cerci broad at base, projecting beyond sheath. *Legs:* Honey-colored except coxae, trochanters of middle and hind legs, proximal portions of middle and hind femora and distal por-

tion of hind tibiae, which are black; middle and hind tarsi dusky brown. Claws with stout inner tooth one-half as long as outer tooth. *Wings:* Hyaline, minutely setiferous on both surfaces; setae dark brown, more numerous toward tips. Nervures pale amber to dark brown, stigma dark brown. Lanceolate cell without crossvein, markedly constricted near base, veins M and lm-cu parallel; M joining R close to fork of Rs; Rs + m distinctly curved; hind wings with two middle cells.

Male. Length 9.5 mm. Head, thorax and first two abdominal tergites shiny black, remainder of abdomen long and slender, reddish-amber; legs honey-colored with basal margins of coxae black and hind tibiae distally and hind tarsi slightly infuscate. Labrum honey-colored, retracted, almost concealed by clypeus. Other characters as in female.

There is less variation in the male than in the female of this species. The greatest deviation from the condition considered as normal in the male is variance in over-all dimensions. A few males have been examined which have small, black patches on the dorsum of abdominal segments three, four and five. Females show a great degree of variation in the amount of black on the abdomen, many having the abdominal tergites almost entirely black while others are almost entirely honey-colored in this area.

The above description was made from four female and four male specimens in the Snow Entomological Museum, University of Kansas. The holotype, female, from California, collected by A. Agassiz, is in the collection of the Cambridge Museum of Comparative Zoology.

A biological study of this species was undertaken concomitantly with the study of the preceding species.

Distribution

Specimens examined by the author have been taken by various collectors in the following localities: British Columbia: Nanaimo Biological Station (June). Washington: Forks (July), *Clallam Co.* and Port Angeles (May). Oregon: Homestead Inn, Mt. Hood (July), Wallawa Mts. (July), *Baker Co.* and Hood River (July). California: Carrville (May), *Trinity Co.;* Shingletown (May), *Shasta Co.;* Yorkville (May), *Mendocino Co.;* Big Bend Mtn. (May), *Butte Co.;* Meadow Valley (June), *Plumas Co.; El Dorado Co.* (June), (specific location not indicated); Lake Tahoe (June), Angora Lake (June) and Fallen Leaf Lake (July), *Placer Co.;* Muir

Woods (Apr.), Mt. Tamalpais (Apr.), Lagunitas (Apr.), Ross (Apr.), Dillon Beach and Taylor State Park (Apr.) and Bear Valley (May), *Marin Co.;* Bubbs Creek Canyon (July) *Fresno Co.;* Yosemite Valley (May), *Merced Co.;* Giant Forest (July) and Sequoia Nat. Park (June), *Tulare Co.;* Leona Heights (Apr.) and Berkeley (Mar., Apr., May, June), *Alameda Co.;* Ben Lomond (June), *Santa Cruz Co.;* Carmel (Mar.), *Monterey Co.;* Bear Valley (June) and San Bernardino Mts. (July), *San Bernardino Co.;* and Keen Camp (June), *Riverside Co.* These distribution records appear to indicate that this species ranges throughout the Pacific Coast region, probably following the same distributional pattern as S. *tibialis.* This species has been taken at altitudes ranging from sea level to 9,700 feet, the latter being the Bubbs Creek record for a male specimen taken in July.

Behavior of Adults

S. *distans* is very similar to S. *tibialis* in many aspects of adult behavior, and it seems redundant to repeat many of the observations made except where some variance or contrast occurs. Collection records, as in the preceding species, indicate that protandry is the rule, a rather common situation in many sawfly species.

Females of this species do not wander about on the stems and branches as do the females of S. *tibialis,* but confine their search for oviposition sites to the tight curls of leaves at the very tip of the fern frond. In preparing to oviposit, the abdomen is characteristically humped and the egg depositing mechanism is applied at right angles to the surface of the plant tissues. Egg insertion takes approximately one minute, after which time the female flies to another frond to repeat the performance. Before alighting upon a frond of suitable maturity for ovipositing, females very often circle it several times, the flight circle diminishing in radius each time or they zigzag in short swoops of descending flight. Egg deposition has been observed only on the succulent growth of the very tip of the frond, although first instar larvae have been taken from similar succulent tips of lateral branches. In captivity a female will oviposit in any tightly coiled portion of the frond. In the field no more than a single larva has been taken from a single coil of plant growth, but confined females have deposited as many as five eggs in one frond tip.

Food of adults of this species appears to be the same as for S. *tibialis,* individuals having been observed to take sap from the host plant and honey water artificially supplied in the rearing chamber.

Males and females have been kept alive in confinement for a maximum of six days and probably could have been kept longer if a more elaborate rearing chamber had been prepared.

The maximum number of eggs deposited by a confined female over a twelve hour period was nine with the total number of eggs laid by a single female during her lifetime of confinement (five days in this instance) being twelve.

LIFE HISTORY

This species requires one year to complete its life cycle. Like the species discussed previously in this paper, the adults emerge in early spring in the San Francisco Bay region of California, appearing concurrently with *S. tibialis*.

Egg stage: As previously noted, eggs are deposited in the coiled apices of the main frond or lateral branches of the host plant, *Pteridium aquilinum*. Insertion is made between the closely spaced branchlets comprising the whorl, the saw blade puncturing the epidermis of the main stem, deposition being made in this spot. The egg may be parallel or diagonal to the main stem and often is only slightly covered with the epidermis of the plant. The portion of the frond where eggs are laid is closely knit with epidermal hairs making the egg accessible only to the very smallest of arthropods. It is thus quite effectively protected from natural enemies.

It may be of interest to cite here from notes taken on oviposition activities of one female sawfly and subsequent inspection of these activities.

A female of this species was observed ovipositing on the curled tip of a *P. aquilinum* on Berkeley campus of the University of California. The sawfly, after completing the egg laying process was captured and taken into the laboratory for positive verification of its identity. The tip of the fern upon which oviposition was observed was also taken into the laboratory for examinatin, careful note being taken of the exact spot where the sheath was observed to have been inserted. In the laboratory a detailed inspection of the bracken was made, care being taken not to tear or injure the plant tissues in any way. Although a careful search was made the egg was not located. On April 25th the bracken was dissected and the egg was located in one of the uppermost, curled, young leaves, inserted partially beneath the epidermis of the main axis in the center of the whorl which itself was only 2 mm. in diameter and situated 4 or 5 mm. from the tip of the frond. Because of the numerous epidermal hairs on leaves and stems the egg was well

concealed and protected. At the time of discovery it was 1.5 mm. long and 1.0 mm. in greatest diameter, a pale yellowish-green in color. This egg hatched on April 27th.

Every egg sought for was almost as difficult to find as the one mentioned above.

Shortly after deposition the egg is 1.35 mm. long and 0.8 mm. in greatest diameter, tapering equally to both ends. Color is glistening opaque white with a faint greenish tinge. The egg case increases in size by stretching as the embryo develops. The dark eye spots and mouth parts are the first definite larval characters to become visible in the embryo. Movement of the embryo within the transparent egg case is similar to that noted in S. *tibialis*. At 72° F. constant temperature eggs hatched in five days.

Larva.—First instar: Length 2.5 mm.; width of head capsule 0.5 mm. Early in this instar the larva is completely colorless except for black ocellarae and ocularia and brownish mouth parts. Later in the instar the head capsule becomes slightly infuscate and the green blood imparts a greenish tinge to the dorsum of the thorax and abdomen.

Second instar: Length 6.5 mm.; width of head capsule 0.8 mm. Color is the same as in the late phase of the previous instar.

Third instar: Length 7.5 mm.; width of head capsule 1.1 mm. Color of thorax and abdomen a slightly darker green than previous instar; head capsule opaque white with a greenish tinge and slightly infuscate on vertex.

Fourth instar: Length 14 mm.; width of head capsule 1.7 mm. Color of thorax and abdomen is pale green with the dorsal vessel imparting the effect of a dark green median dorsal stripe delimited laterally by conspicuous white stripes. Main tracheal trunk connecting spiracles appears as a threadlike, white, lateral line. Head capsule is opaque white with a greenish tinge and with two, small, fuscous patches on dorsum of vertex.

Fifth instar: Length 19 mm.; width of head capsule 2.0 mm. This is the ultimate larval instar and is identical in appearance to the previous instar. Immediately prior to entering dead wood for pupation the larva becomes a purplish-brown color.

Larvae cast their skins in the same manner as described for S. *tibialis*. The following is a description in detail of an early fifth instar larva of S. *distans:*

Head subglobose, opaque white with greenish tinge, infuscate pattern of irregular shaped, small blotches on dorsum of vertex;

front and genae sparsely setiferous. Ocellarae and ocularia black. Antennae conical, broad at base, five-segmented, all segments opaque white, segments two, three and four with slitlike sensory pits, one and five with small, round pits. Antacoriae large, round, nearly equal in diameter to ocularia. Clypeus truncate, with four stout spines. Labrum rounded truncate with shallow involution at apex, armed with ten stout spines. Maxilla with five-jointed palpus, distal margin of fourth segment with five stout bristles, three stout spines on first and one on anterolateral margin of third segment, four smaller setae on second segment; galea flattened, curved inward, anterior margin with numerous pits; lacinia flattened, anterior margin with ten to thirteen elongate and broad spines. Labial palpi with three segments. Labium rounded truncate. Mandibles quadridentate, brown.

Thorax with prominent, winged, dark brown spiracles located midlaterally on prothoracic segment. Spiracles absent on remainder of thorax. Thoracic legs normal in form, five-segmented, setiferous, tarsal claws not toothed.

Abdomen robust, tapered slightly caudad. Uropods occur on segments two through eight inclusive and ten. Spiracles dark brown, winged, conspicuous, narrowly ovate; prothoracic spiracle largest, abdominal spiracles all of same size, situated slightly ventrad to a midlateral position on second annulet. Abdominal segments seven-annulate, setae in sparse, single-row arrangement on second, fourth and seventh annulations.

Glandubae distributed over most of body, on abdomen occurring dorsally and dorsolaterally only on setiferous annulations; most numerous ventrolaterally on thorax and abdomen; none on head capsule.

Behavior of Larva

Upon emergence from the egg the larva remains in the vicinity of the apical whorls of leaves of the host clinging to the densely haired lower surfaces of the leaflets upon which they feed. The body is usually stretched out flat against the under surface of the leaflet. Larvae remain on apical leaves of fronds until the fourth instar is reached, at which time the desire for a much greater volume of less succulent food material appears to stimulate a descent of the frond to lateral branches with more mature leaflets. Larvae of the two species, *S. tibialis* and *S. distans*, frequently may be found side by side on fern branchlets, late instar larvae being differentiated most readily by the more conspicuous, dorsolateral,

white, longitudinal stripes on the thorax and abdomen of S. *distans*. This character is not always reliable in differentiating the two species, but an examination of the antennae with a hand lens will disclose either the pale type of S. *distans* or the black segments of S. *tibialis*. Also the presence of two, distinct, fuscous patches on the dorsum of the vertex characterizes S. *distans*.

The ultimate larva of S. *distans* may feed for five or six days before search is initiated for suitable dead wood material for penetration and construction of the pupation cell. Shortly after feeding is discontinued the color of the larva metamorphoses from green to purplish-brown. A tunnel is excavated in dead wood by chewing away the material with the mandibles, pushing the frass to the exterior with the palpi, thoracic legs and uropods. Often the tunnel entrance can be detected by the accumulation of frass beside it or below it on the ground. Extent of penetration of wood and construction of the pupal chamber within is very similar to that observed in S. *tibialis* although the diameter of the tunnel is slightly larger, in order to accommodate the more robust larva. Typical cells are almost 16 mm. long and 3.5 mm. in diameter. As in S. *tibialis*, the chamber proper, sealed off at the entrance and with a frass plug, is not lined in any manner with silken threads or other larval exudate, the quiescent larvae being in naked contact with the wood. However, the sides of the chamber are smoother than the forward part of the tunnel beyond the plug. Larvae examined several months after entering wood were greenish-brown in color, shrunken in length and somewhat shriveled in appearance. Very little movement was elicited when disturbed. If suitable dead wood material is not placed in the rearing chamber for availability to ultimate larva, death inevitably ensues after a prolonged ambulatory search has been made for this requirement. Death is probably due to starvation, for once the larva ceases to feed it cannot be induced to resume feeding and the continued wandering about no doubt starves the tissues which normally would require little nutrition with the larva quiescent in the pupal chamber. Larvae are very similar to S. *tibialis* in behavior patterns, having the same characteristic habits of dropping to the ground or whipping the abdomen back and forth when disturbed.

Pupa: Due to the destruction of cultures by molds, a detailed study of this stage of development has not been made. However, this stage has been reared by T. O. Thatcher in the laboratory. Doctor Thatcher was kindly permitted the inclusion in this paper

of his notes taken on the species: "Three larvae were collected 31 May 1946, 6 mi. N. Willets, California, by F. D. Thatcher as they were boring into unseasoned redwood lumber. One survived long enough to bore completely into the wood. It appeared as a shrunken larva until 8 March 1947; it was a pupa when examined 11 March 1947. The larvae were green, with a rather felty appearance similar to *Pieris rapae*. The pupa was bright blue-green in head, thorax and legs and brown neutral in abdomen. On 17 March 1947 the thorax, head and legs had turned very dark, almost black and the abdomen had lost most of its brownish tinge. The pupa was active when disturbed. The adult emerged on 21 March 1947. It had black head and thorax and red-brown abdomen; the insect's left wings did not fully extend." This specimen was subsequently identified by the present author as a male *Strongylogaster distans* Norton.

Summary of life cycle: At 72° F. constant temperature eggs hatched in five days. With this temperature maintained the duration of instars is as follows: First instar, two to four days; second instar, one to two days; third instar, two to four days; fourth instar, four to seven days; fifth instar, four to six days. Time interval for the fifth instar is for active larva only, the quiescent phase of this instar being in the neighborhood of ten and one half months. The true pupal stage endures approximately ten days. Thus, the species is in the egg stage normally for about one week, an active larva for two to four weeks, a quiescent larva for about ten months and a pupa for two weeks. Longevity of the adult in the field has not been determined, although its life span is probably two or three weeks judging from collection records.

Host Plants

It seems unnecessary here to repeat data on host plant selection, for the same information given in the discussion of *S. tibialis* applies. The only known host for *S. distans* is common bracken, *Pteridium quilinum*. Neither oviposition nor larval feeding has been observed on other species of ferns.

Natural Enemies

The greatest natural enemy of this species, as in *S. tibialis*, appears to be fungus attack upon the aestivating and hibernating larval stage. Insect parasites and arthropod predators have not to date been observed to interfere with this sawfly in any of

its developmental nor mature stages. No diseases other than fungus attacks noted above have been seen.

ECONOMIC IMPORTANCE

This sawfly occurs commonly in association with S. *tibialis* and contributes to the damage wrought upon ornamental plantings of the host plant, and with this consideration it may be designated as a definite pest. This sawfly as well as the preceding species, may be considered as being beneficial in the respect that it destroys the foliage of a plant of common occurrence in range and pasture lands which is known to be toxic to livestock. However, the writer has not seen defoliation of stands of bracken to a degree where the activity of larval feeding appreciably reduced the plant stand in a range or pasture area.

The greatest and most conspicuous plant damage appears to occur in small, isolated stands of bracken, such as are encountered in ornamental garden plantings. These are subject to prolific egg deposition.

CONTROL

The same methods as recommended for the previous species also apply to the control of S. *distans*. For this information the reader is referred to the earlier section on control.

ACKNOWLEDGMENT

The author is indebted to Dr. Ray F. Smith of the University of California for assistance rendered in comparing specimens of both species included in this paper with the types.

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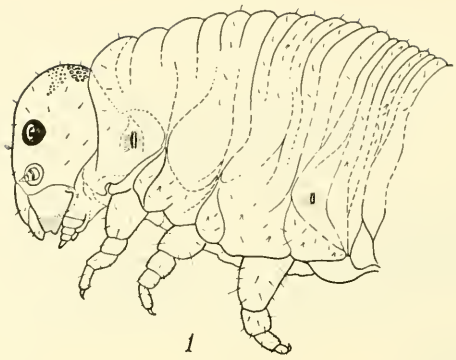
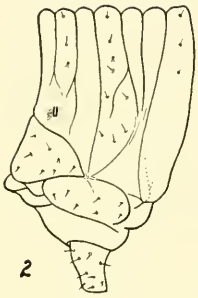
PLATE I

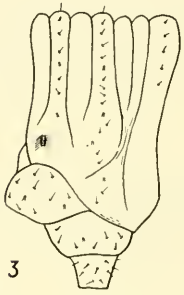
FIG. 1—*Strongylogaster tibialis* Cresson. Fifth instar larva on branch of host plant, *Pteridium aquilinum*.

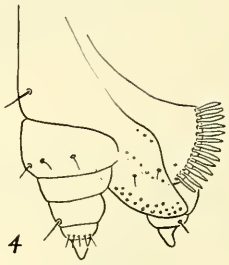
FIG. 2—*Strongylogaster distans* Norton. Fourth instar larva on branch of host plant, *P. aquilinum*.

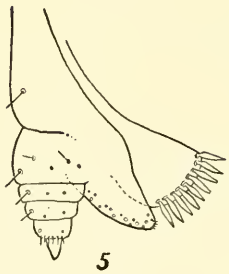
PLATE II

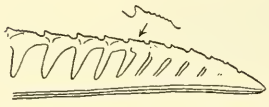


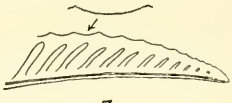












LARVAL CHARACTERS

FIG. 1—*Strongylogaster distans.* Lateral aspect of anterior portion of body of fifth instar larva.

FIG. 2—S. *tibialis.* Third abdominal segment.

FIG. 3—S. *distans.* Third abdominal segment.

FIG. 4—S. *distans.* Maxilla and labial palpus.

FIG. 5—S. *tibialis.* Maxilla.

FIG. 8—S. *distans.* Antenna and antacoria.

FIG. 9—S. *tibialis.* Antenna and antacoria.

ADULT CHARACTERS

FIG. 6—S. *distans.* Saw.

FIG. 7—S. *tibialis.* Saw.

PLATE III

Portion of frond of *Pteridium aquilinum* showing damage caused by larval feeding of *Strongylogaster tibialis* and *S. distans*.

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Trombicula gurneyi Ewing and Two New Related Chigger Mites (Acarina, Trombiculidae)[1,2]

BY RICHARD B. LOOMIS

ABSTRACT.—The larva of *Trombicula gurneyi* Ewing is redescribed. *Trombicula hamertoni* Radford is considered a synonym. This chigger mite is an inhabitant of eastern woodlands. *Trombicula gurneyi campestris* subsp. nov. is described from larvae taken on grassland vertebrates of the western parts of Nebraska, Kansas and Oklahoma. *Trombicula kansasensis* sp. nov., closely related to *Trombicula gurneyi*, is known at present only from Kansas. The author considers these two species as a separate group, the gurneyi group, of the genus *Trombicula, sensu lato.*

INTRODUCTION

Taxonomic and ecological studies of the larval chigger mites of the genus *Trombicula* from the central United States have disclosed two closely related species, which cannot be placed in any of the described subgenera, as defined by Wharton and Fuller (1952:42). One of the species, *Trombicula gurneyi* Ewing, has been found in the southeastern and central states. *Trombicula hamertoni* Radford, from an unknown locality, but probably from one of the southeastern states, is considered synonymous with *T. gurneyi*. A new subspecies, *Trombicula gurneyi campestris*, is described from the western parts of Nebraska, Kansas, and Oklahoma. The second species, *Trombicula kansasensis* sp. nov., is known from the state of Kansas. *Trombicula kansasensis* has been found in the same localities as *Trombicula gurneyi* and in western Kansas, both species were recovered from the same hosts. *Trombicula kansasensis* and *T. gurneyi* have both been found to occur on reptiles and mammals, while the latter species was also recovered from birds. The

1. The studies upon which this paper is based were conducted in part under a contract N6 ori 220 Task Order II, between the University of Kansas and the Office of Naval Research.

2. Contribution No. 877 of the Department of Entomology, University of Kansas.

known period of larval activity of *T. gurneyi* is spring to late fall and that of *T. kansasensis* is summer to late fall.

Since these two species cannot be placed in any of the named subgenera, I propose that they be considered together as the "gurneyi" group of the genus *Trombicula*. The characters shared in common include the bifurcate palpal claw, having axial prong internal; scutum roughly rectangular; sensilla flagelliform with distal branches; galeal seta nude; two pairs of sternal setae; leg III with coxa having only one branched seta and without long, nude, whiplike setae; body setae total 44; and palpal femur with seta branched.

ACKNOWLEDGMENTS

I wish to thank Dr. E. W. Baker, Insect Identification Section, United States Department of Agriculture, for the loan of a cotype of *Trombicula gurneyi* and Dr. G. Owen Evans, Custodian of Acarina, British Museum (Natural History) and Dr. Charles D. Radford for sending descriptions of critical characters of *T. hamertoni*. For aid in the assembly of larvae reported below, grateful acknowledgments are extended to the following persons formerly or now at the University of Kansas: Mr. D. A. Crossley, Jr., Mr. Harold A. Dundee, Dr. Henry S. Fitch, Mr. Robert B. Finley, Jr., Mr. J. Knox Jones, Jr., Mr. Ervin H. Kardos, Mr. Louis J. Lipovsky, Mr. Olin L. Webb and other members of the departments of Entomology and Zoology. The writer also wishes to thank Mr. Crossley, Dr. Fitch and Dr. Charles D. Michener of the University of Kansas for carefully reading and criticizing the manuscript.

ACCOUNTS OF SPECIES AND SUBSPECIES

The terminology used throughout the paper is that of Wharton, *et al* (1951). All of the measurements are in microns. The description of each new form is based upon the holotype, with differences among the paratypes indicated in parentheses. Unless otherwise indicated, the specimens listed are in the Snow Entomological Museum, University of Kansas, with the slide numbers preceded by the initials KU. The number in parentheses in the listing of specimens denotes the number of larvae examined.

Trombicula gurneyi gurneyi Ewing

Figures 1-5; Table 1

Trombicula gurneyi Ewing, Proc. Biol. Soc. Washington, vol. 50, p. 169, Oct. 28, 1937, type from Priest Bridge, Patuxent River, Maryland, host *Eumeces fasciatus*, April 24, 1937; Fuller, Zool. Verhandelingen, no. 18, p. 99, 1952; Wharton and Fuller, Mem. Ent. Soc. Washington, no. 4, pp. 65-66, Dec. 10, 1952.

Eutrombicula gurneyi, Ewing, Jour. Washington Acad. Sci., vol. 28, p. 294, 1938; Radford, Parasitology, vol. 34, p. 67, 1942.
Trombicula hamertoni Radford, Parasitology, vol. 34, p. 62, fig. 28, 1942, (type from unknown locality, host probably *Elaphe guttata*, from the London Zoo, March 8, 1939); Radford, Proc. Zool. Soc. London, vol. 116, p. 589, figs. 15-16, 1946; Radford, Proc. Zool. Soc. London, vol. 117, p. 275, 1947; Fuller, Zool. Verhandelingen, no. 18, p. 99, 1952; Wharton and Fuller, Mem. Ent. Soc. Washington, no. 4, p. 66, 1952. *New synonymy.*
Acariscus gurneyi, Ewing, Proc. Ent. Soc. Washington, vol. 45, pp. 57-59, 1943 (in part).
Trombicula (*Eutrombicula*) *gurneyi*, Thor and Willmann, Das Tierreich, Lief. 71, p. 291, 1947.

Diagnosis: Larva with body setae total 44, dorsal setae 22, beginning 2-6-6, ventral setae 22, with two pairs of sternal setae; eyes 2/2 on faintly visible ocular plate; scutum roughly rectangular, wider than long, with sinuous margin, PL seta nearly twice length of AL seta, AM seta short, average 27μ (25-30μ); sensilla flagelliform with 8 to 10 distal branches; galeal seta nude; palpal femur with branched seta, tibia with three nude setae; palpal claw bifurcate, axial prong internal; leg I with tarsala * short (13μ); leg III coxa with 1 seta, without whiplike setae. Similar to *Trombicula gurneyi campestris* subsp. nov. and *Trombicula kansasensis* sp. nov., with differences listed under their diagnoses.

Description of larva: Based upon a cotype, USNM 1262, with differences among other specimens indicated. Condition of cotype examined, poor, lacking sensillae and anteromedian seta. Specimen originally prepared in KOH, thus making many characters indistinct or obscure.

Body: Cotype 187 by 150 (partially engorged), larvae from Kansas (unengorged) 170 by 148 and (engorged) 394 by 297; color yellow to orange (engorged) to whitish (unengorged) in life. Eyes 2/2, red in life; posterior lens indistinct, ocular plate faintly outlined.

Dorsal setal formula 2-6-6-4-2-2, total 22; humeral seta measures 46, anterior dorsal seta 40, posterior dorsal seta 35. Ventral setal formula 2-2-6-4-4-4, total 22, anterior seta measures 35, anterior ventral seta 28, posterior ventral seta 27. Total body setae 44.

Scutum: Shape roughly rectangular, wider than long, lateral margin emarginate, posterior margin poorly defined in cotype, but slightly sinuous, punctae small and moderately numerous, posterolateral seta nearly twice length of anterolateral seta; bases of sensillae nearly equidistant between anterior and posterior margins, and nearly in line with mid-points between lateral setae. Sensillae

* See Audy (1952:152) for the use of tarsala and microtarsala in place of spur and microspur on the tarsi.

(absent in cotype) flagelliform, with 8 to 10 branches on distal two thirds in specimens from Kansas and other central states. For scutal measurements, see Table I.

Gnathosoma: Cheliceral blade long and slender, slightly curved with one prominent dorsal tricuspid cap and a prominent ventral projection; galeal seta nude. Capitular sternum with one pair of branched setae. Palpal femur with one branched seta; genu with one nude seta; tibia with three nude setae; tarsus with one stout basal tarsala (7μ), one slender nude seta (subterminala), and five branched setae; palpal claw bifurcate, prongs nearly equal in length, inner prong axial, ventral and curved slightly inward.

Legs: Leg I coxa, trochanter and basifemur each with one branched seta; telofemur with five branched setae; genu with four branched setae, three genualae and a microgenuala; tibia with eight branched setae, two tibialae and a microtibiala; tarsus with approximately twenty branched setae, tarsala (13μ), microtarsala, subterminala, parasubterminala and pretarsala. Leg II coxa and trochanter each with one branched seta; basifemur with two branched setae; telofemur with four branched setae; genu with three branched setae and a genuala; tibia with six branched setae and two tibialae; tarsus with approximately sixteen branched setae, tarsala (13μ), microtarsala and a pretarsala. Leg III coxa and trochanter each with one branched seta; basifemur with two branched setae; telofemur with three branched setae; genu with three branched setae and a genuala; tibia with six branched setae and a tibiala; tarsus with approximately fourteen branched setae (no long, nude, whiplike setae).

Taxonomic remarks: Although the writer was not able to examine the holotype of *Trombicula hamertoni*, a description of it was given to me by Dr. Evans of the British Museum (Natural History). This description compared favorably in every detail with cotype of *T. gurneyi* and with specimens referred to *T. g. gurneyi* from the eastern half of the United States. Radford (1942:56) stated that this type of *Trombicula hamertoni* was found in a "tube containing the lungs or air sac of a Corn snake (*Elaphe guttata*)". The tube was sent to Dr. Radford by Col. A. E. Hamerton, Pathologist of the London Zoo. The locality from which this snake was secured is unknown. If the identification of the snake was correct, and the larva actually came from the snake in question, it is probable that this *Elaphe guttata* was originally from one of the southeastern states, since the range of *Elaphe guttata guttata* (Linnaeus)

is confined to the Gulf and Atlantic coastal states, extending no farther westward than Louisiana and Kentucky.

Geographic distribution: Known from Maryland (type locality), central Florida (Lake County), southern Louisiana (St. Tammany, and St. Charles Parishes), eastern Texas (Titus-Red River County line and Travis County), southwestern Arkansas (Little River County), eastern and central Oklahoma (Haskell and McClain counties north to Creek County), eastern Kansas (Bourbon County north to Doniphan County) and southeastern Nebraska (Nemaha County). Intergrades with *Trombicula gurneyi campestris* subsp. nov. are known from south-central Kansas (Barber County).

Ecology: Larvae of this subspecies have been taken in eastern Kansas on thin black rectangular plastic plates (chigger samplers) which were placed upon rotten stumps, logs and associated decaying wood surrounding them. They were found to be abundant in this habitat in deciduous forests in May to early October. The hosts of the larvae were found to be those species which commonly inhabit woodlands and regularly come into contact with this larval habitat. The negative evidence supplied by examination of many different grassland dwelling hosts and by chigger sampling of other habitats in the known season of *T. g. gurneyi,* supports the idea that decaying wood, especially logs, stumps and standing dead trees, is the habitat of the free-living stages, and that the hosts are infested with larvae when they move over these surfaces or rest on them. The nymphs and adults which have been taken from the center of large decaying logs in northeastern Texas, in March, support this theory.

In eastern Kansas, the five-lined skink, *Eumeces fasciatus* Linnaeus, seems to be the principal host. This lizard is not only abundant in the known habitat of the larvae, but it has been found to harbor numerous larvae throughout the season of larval activity. As many as 100 larvae have been found on a single adult skink. The larvae attach to these lizards between the toes, and on the axilla, groin, head and neck under protective scales. The daily and seasonal activity of both the lizards and the larvae seem to be approximately the same.

The western part of the range of *Eumeces fasciatus* is superimposed on the map (fig. 1) of *Trombicula gurneyi,* and shows the similarity of ranges between this skink and the eastern subspecies, *T. g. gurneyi.* This western part of the range of *E. fasciatus* also closely coincides with the extent of larger stands of deciduous wood-

lands. West of this range the woods which are present are usually limited to a few scattered trees in the stream valleys. This habitat does not seem suitable for *Eumeces fasciatus.* The intergrades between *T. g. gurneyi* and *T. g. campestris* however were taken in this type of habitat. It is probable that *T. g. gurneyi* will be found throughout most of the range inhabited by the five-lined skink.

The usual sites of attachment on mammals seemed to be on the body, base of the tail and the upper part of the legs. They were especially common in the areas surrounding the anus and genitalia. The larvae were attached under the lateral and ventral scales of snakes.

In northeastern Kansas, the larvae appear in late April and early May, closely following the appearance of warm spring weather. They are numerous in the late spring and summer, decreasing in number on hosts and chigger samplers in late September and early October, disappearing completely in November. The amount of moisture present in the fall seems to determine the abundance of active unengorged larvae and the time of their disappearance. The lower temperature in October and November also seems to contribute to the decline and the complete disappearance of the larvae. A single unengorged larva was obtained from nest material of the wood rat, *Neotoma floridana,* on February 17, 1952, in central Oklahoma (McClain County). This larva probably hatched from an egg in the nest material as it was heated in a Berlese funnel to recover arthropods. No larvae of *Trombicula gurneyi* were recovered from five wood rats examined from the same locality in March and early April, the first larva being taken on April 14, 1952.

Larvae of this subspecies were common on lizards in eastern Oklahoma in early April (April 8, 1950).

Specimens examined: Total 355 larvae, as follows. MARYLAND. *Prince Georges Co.:* Priest Bridge, Patuxent River, *Eumeces fasciatus,* April 24, 1937, USNM 1262 (cotype). FLORIDA. *Lake Co.:* Plymouth, on decayed oak tree, Aug. 21, 1947 (1). LOUISIANA. *St. Tammany Parish:* 8 mi. SE Slidell, April 30, 1954, *Eumeces inexpectatus* (8) and *Sceloporus undulatus* (2). *St. Charles Parish:* 17 mi. SW New Orleans, *Lampropeltis getulus,* May 1, 1954 (2). TEXAS. *Titus Co.—Red River Co.* border: 3 mi. NW Talco, Sulphur River bottoms, adults from decaying logs, March 26, 1948 (21). *Travis Co.:* 5 mi. W Austin, *Uta ornata,* April 23, 1954 (1). ARKANSAS. *Little River Co.:* 5 mi. SE Ashdown, May 3, 1954, *Eumeces fasciatus* (4), *Eumeces laticeps* (5). OKLAHOMA. *Cherokee Co.:* 2 mi. W

Cookson, *Sceloporus undulatus*, May 6, 1950 (4). *Creek Co.:* 7 mi. SW Tulsa, Parthenes Park, *Eumeces fasciatus*, April 8, 1950 (8). *Haskell Co.:* 4 mi. S, 3 mi. E Quinton, *Eumeces fasciatus*, April 9, 1950 (1). *McClain Co.:* 8 mi. SW Norman, *Neotoma floridana*, April 14, 1952 (1) and nest, Febr. 17, 1952 (1). *Rogers Co.:* 6 mi. E Catoosa, *Eumeces fasciatus*, April 8, 1950 (12). *Wagoner Co.:* 2 mi. S Okay, *Eumeces fasciatus*, April 8, 1950 (3).

Kansas. *Bourbon Co.:* 1 mi. W Ft. Scott, *Peromyscus leucopus*, Sept. 4, 1947, (1); 2 mi. E Hiattville, *Elaphe obsoleta*, May 10, 1953 (1). *Doniphan Co.:* 2 mi. N White Cloud, *Peromyscus leucopus*, Aug. 21, 1948 (2). *Douglas Co.:* 1 mi. W Clinton, *Eumeces fasciatus*, May 10, 1952 (2); 1½ mi. E Eudora, *Eumeces fasciatus*, April 20, 1950 (5), April 30, 1950 (8) and May 11, 1952 (2); Lawrence, *Elaphe obsoleta*, July 22, 1951 (6) and *Scalopus aquaticus*, Nov. 10, 1948 (1); 3½ mi. E, 4 mi. S Lawrence, May 15, 1948, *Eumeces fasciatus*, (1) and *Elaphe obsoleta*, (1); 5 mi. N, 1 mi. E Lawrence, Univ. Kansas Nat. Hist. Reserv., *Chigger samplers*, all in 1952, May 25 (5), May 31 (1), June 30 (11), July 16 (2), Aug. 20 (2), Sept. 3 (4), Sept. 17 (10), Sept. 23 (1), Oct. 2 (4), -*Eumeces fasciatus*, May 9, 1950 (40), May 11, 1950 (8), May 13, 1952 (4), May 16, 1948 (2), May 21, 1952 (5), June 4, 1952 (1), June 20, 1952 (1), June 28, 1952 (2), June 30, 1952 (2), July 15, 1951 (12), Aug. 16, 1952 (5), -*Crotalus horridus*, Sept. 2, 1953 (7), -*Elaphe obsoleta*, May 16, 1948 (6), Sept. 10, 1952 (1), -*Blarina brevicauda*, July 2, 1952 (1); 20 mi. SW Lawrence, *Sciurus niger*, Sept. 20, 1953 (1); Lone Star Lake, *Eumeces fasciatus*, April 24, 1948, (4); ½ mi. N Pleasant Grove, *Eumeces fasciatus*, May 20, 1949 (55); 1½ mi. S, 1½ mi. E Pleasant Grove, *Eumeces fasciatus*, April 30, 1950 (7). *Jefferson Co.:* 8 mi. N, 1 mi. E Lawrence, *Elaphe obsoleta*, June 27, 1952 (2); 2½ mi. E, 4 mi. N Williamstown, *Peromyscus leucopus*, April 29, 1952 (2). *Johnson Co.:* 1 mi. E Sunflower, *Eumeces fasciatus*, April 30, 1950 (8). *Miami Co.:* 3 mi. E, 1 mi. S Fontana, Pigeon Lake area, *Elaphe obsoleta*, Oct. 12, 1948 (1), -*Eumeces fasciatus*, May 13, 1950, (6), May 26, 1951 (5) and May 31, 1953 (1), -*Eumeces laticeps*, May 13, 1950 (7), May 26, 1951 (2), -*Sciurus carolinensis*, May 31, 1953 (3), -*Chigger Sampler*, May 30, 1952 (4), Sept. 9, 1953 (4). Nebraska. *Nemaha Co.:* 3 mi. S, 1½ mi. E Peru, *Peromyscus leucopus*, Oct. 9, 1953 (1).

Trombicula gurneyi campestris subsp. nov.

Figure 1; Table 1

Types: Larvae: Holotype, KU. 3924, and 22 paratypes, KU. 3802-04, 3807-11 and 3925-39, Snow Entomological Museum, University of Kansas, from 13 miles south, 6 miles east of McDonald, Rawlins County, Kansas, taken from three thirteen-lined ground squirrels, *Citellus tridecemlineatus* (Mitchell), field no. RL 490807-9, shot on August 7, 1949, by R. B. Loomis and Robert E. Elbel.

Diagnosis: Larva similar to *Trombicula gurneyi gurneyi* Ewing, but differs principally in the longer anteromedian (AM) scutal seta, average 37μ (35-40μ), several scutal measurements average larger with sensilla longer having branches nearer distal end. See table I for comparison of scutal measurements.

Description of larva: Similar to *T. g. gurneyi* Ewing, except for the following characters including measurements of the type series.

Body: Holotype (partially engorged) 300 by 250, (engorged 380 by 331), color, yellow to whitish in life. Eyes 2/2, red in life, ocular plate faint. Humeral seta measures 43, anterior dorsal seta 36, posterior dorsal seta 35, ventral setae 22, anterior and posterior sternal setae measure 33, anterior ventral seta 29, posterior ventral seta 31.

Scutum: Sensilla flagelliform, long with several basal barbs and 10-13 long distal branches. Scutal measurements of holotype: AW- 66, PW- 76, SB- 31, ASB- 22, PSB- 16, AP- 18, AM- 36, AL- 25, PL- 44, S- 52. See table I for the measurements of additional specimens.

Gnathosoma: Palpal genual seta occasionally with a single branch.

Legs: Tarsalae I and II short, 12-13μ.

Taxonomic remarks: The morphological differences between the two subspecies are slight; however these characters seem to be constant throughout each of the known geographic ranges. The specimens considered as intergrades are geographically and morphologically intermediate.

The name *campestris* refers to the plains and field habitat of this subspecies, in contrast to the woodland habitat of the typical subspecies.

Geographic distribution: Known from southwestern and south-central Nebraska (Hitchcock and Webster counties), western and central Kansas (Cheyenne, Rawlins, Wallace, Jewell, Seward and

Barber counties), eastern Colorado (Yuma County), and western Oklahoma (Woods, Harper and Harmon counties). Intergrades with *T. g. gurneyi* are known from south-central Kansas in Barber County.

Ecology: Trombicula gurneyi campestris seems to have ecological requirements different from those of typical *gurneyi*, being found on small mammals, birds and reptiles that inhabit the grasslands of the high plains. The burrows and underground nests of small grassland mammals seem to provide the habitat of the free-living stages. The nests and surrounding materials maintaining favorable temperature and humidity, may actually approach the microhabitat of the eastern subspecies, which lives in decaying wood.

Larvae of this subspecies have been taken on 8 species of mammals, 1 species of bird, and 7 species of reptiles. The single bird record, from the burrowing owl, *Speotyto cunicularia*, as well as the other records all support the theory that the free-living larvae inhabit nests and burrows.

The larvae of this subspecies have been taken on hosts as early as April 12 in southwestern Oklahoma and were common from July to October in western and central Kansas.

The usual site of larval attachment upon mammals was observed to be around the anus and genitalia. Larvae were found under the anterolateral and ventral scales of snakes and on the legs and wings of birds.

The larvae considered intergrades between the two subspecies were obtained in a valley supporting a stand of timber, mostly elm and cottonwood. Numerous dead trees were present which afforded the habitat of decaying wood characteristic of the eastern subspecies. This locality is approximately 5 miles east of the nearest station of typical *campestris*.

Specimens examined: Total, 231 larvae, as follows. Colorado. *Yuma Co.:* 20 mi. W St. Francis, Kansas, *Masticophis flagellum*, Aug. 6, 1949, KU 3911. Nebraska. *Hitchcock Co.:* 13 mi. S, 2 mi. W Trenton, *Citellus tridecemlineatus*, Aug. 8, 1949, KU 3909-10 (total 3). *Webster Co.:* 3 mi. E Guide Rock, *Heterodon nasicus*, Aug. 5, 1951, KU 3908. Kansas. *Barber Co.:* 2 mi. E Aetna, *Dipodomys ordi*, Sept. 14, 1953 (6); 4 mi. S Aetna, *Neotoma micropus*, July 25, 1952, KU 7078, Sept. 15, 1953 (2); *-Peromyscus leucopus*, July 26, 1952, KU 3881 and *Sylvilagus floridanus*, Sept. 14, 1953 (1); 4 mi. S, 2 mi. E Aetna, *Dipodomys ordi*, Aug. 22,

1949, KU 3877-80; 5 mi. S, 3 mi. E Aetna, *Masticophis flagellum*, Sept. 14, 1948, KU 324, 3832-75 and 4; 10½ mi. W Hardtner, *Melanerpes erythrocephalus*, KU 3883-87 and *Sylvilagus floridanus*, KU 3882, July 26, 1952, considered intergrades between *Trombicula g. gurneyi* and *T. g. campestris;* 17 mi. W Medicine Lodge, *Arizona elegans*, Sept. 14, 1948, KU 3876. *Cheyenne Co.:* 3-5 mi. N St. Francis, *Onychomys leucogaster*, July 23, 1948, KU 287-88, 3757; 4 mi. E, 4 mi. N St. Francis, *Onychomys leucogaster*, KU 289, 3772-86, 3912-17, Total 30, and *Peromyscus maniculatus*, KU 3758-71, July 24, 1948; 6 mi. S, 2 mi. E Benkelman, Nebr., *Perognathus hispidus*, Aug. 7, 1949, KU 3787-89, 3918-23. *Jewell Co.:* 1 mi. E, ½ mi. N Lovewell, *Lampropeltis triangulum*, July 3, 1951, KU 3831 (3); 4 mi. W Lovewell, *Eumeces obsoletus*, July 10, 1951, KU 3830. *Rawlins Co.:* 3½ m. S Atwood, *Perognathus hispidus*, Aug. 8, 1949, KU 3820; 6 mi. S Atwood, *Perognathus hispidus*, July 30, 1948, KU 1592, 3800-01, 4½ mi. E Atwood, *Crotalus viridis*, Aug. 7, 1949, KU 3815-19 (total 8); 9 mi. W, 1½ mi. S Atwood, *Peromyscus maniculatus*, Aug. 10, 1949, KU 3825; near Beardsley, *Citellus tridecemlineatus*, July 26 and 28, 1949, KU 3790-99; 9 mi. S Beardsley, *Crotalus viridis*, KU 3823 (2) and *Peromyscus maniculatus*, KU 3824, Aug. 9, 1949; 13 mi. S, 6 mi. E McDonald, *Citellus tridecemlineatus*, KU 3802-11, 3821-22, 3924-41, *-Cynomys ludovicianus*, KU 7116, and *-Speotyto cunicularia*, KU 3812-14 (total 5), Aug. 7-8, 1949. *Seward Co.:* 12 mi. NE Liberal, *Perognathus hispidus*, Sept. 10, 1948, KU 3826-29. *Wallace Co.:* 3 mi. W Sharon Springs, *Peromyscus maniculatus*, July 4, 1949, KU 3750-56 (total 9).

Oklahoma. *Harmon Co.:* 8 mi. N, 3 mi. W Vinson, *Eumeces obsoletus*, April 12, 1950, KU 3903. *Harper Co.:* 10 mi. N Buffalo, *Citellus tridecemlineatus*, April 12, 1950, KU 3904-07. *Woods Co.:* 6 mi. S, 2 mi. W Aetna, Kansas, *Heterodon platyrhinos*, Oct. 7, 1951, KU 3888-89, *-Masticophis flagellum*, Aug. 22, 1949, KU 3891-3902; 7½ mi. S, 5 mi. E Aetna, *Dipodomys ordi*, July 26, 1952, KU 3890.

Trombicula kansasensis sp. nov.

Figure 6; Table 1

Types: Larvae: Holotype, KU slide number 3701 and 16 paratypes, KU 3702-3710 and 3713-3719, taken from two bull snakes, *Pituophis catenifer* (Blainville), trapped on October 17, 1950, by Dr. Henry S. Fitch, and 12 paratypes, KU 3720-30, taken from a deer mouse, *Peromyscus maniculatus* (Wagner), field

number RL511020-3, obtained on October 21, 1951, by R. B. Loomis, all from the University of Kansas Natural History Reservation, 5 miles north and 1 miles east of Lawrence, Douglas County, Kansas.

Diagnosis: Larva similar to *Trombicula gurneyi* Ewing, but differs in having longer anteromedian AM scutal seta, average 47μ (45-50μ); longer tarsalae I and II (16μ); longer sensilla, average 69μ (64-74μ); larger scutum (see table I); and eyes 1/1, without visible ocular plate.

Description of larva: Similar to *Trombicula gurneyi* in most characters, but differs as follows.

Body: Holotype (engorged) 478 by 366, color yellow to whitish in life; eyes 1/1, red in life, ocular plate absent, diameter of lens 6μ. Humeral seta measures 53, anterior dorsal seta 43, posterior dorsal seta 53, anterior sternal seta 43, posterior sternal seta 41, anterior ventral seta 34, posterior ventral seta 40.

Scutum: Punctate; large (see table I); sensilla long with several basal barbs and 9-10 long distal branches. Scutal measurements of holotype: AW- 72, PW- 86, SB- 37, ASB- 27, PSB- 18, AP- 19, AM- 49, AL- 30, PL- 50, S- 68. See table I for scutal measurements of additional specimens

Gnathosoma: Palpal claw bifurcate, with deep cleft between longer inner axial prong and smaller outer prong.

Legs: Tarsalae I and II, 16μ.

Geographic distribution: Known only from western (Wallace County), south-central (Barber County) and northeastern (Douglas County) Kansas.

Ecology: *Trombicula kansasensis* and *T. g. gurneyi* have been taken in the same general area in Douglas County, but they were found on different hosts collected in different habitats. *Trombicula kansasensis* and *T. g. campestris* were both taken from the same individual hosts in Barber and Wallace counties, which indicates a close similarity of habitat for these latter kinds of larvae.

Larvae were taken from hosts in July to mid-October. The species seems to be common in open rocky situations, and the type series was obtained from hosts inhabiting an abandoned limestone quarry at the University of Kansas Natural History Reservation. The hosts from Barber County were taken in sandstone, gypsum canyons.

The common sites of attachment of the larvae were under the anterolateral and ventral scales of snakes, and on the bodies of

the mammalian hosts. The larvae from the paratype host, *Peromyscus maniculatus,* were found along the penis, near the anus and surrounding the base of the tail.

Specimens examined: Total, 69 larvae, as follows. KANSAS. *Barber Co.*: 4 mi. S Aetna, *Neotoma micropus,* Aug. 22, 1949, KU 3743, Oct. 6-7, 1951, KU 3735-36, Sept. 15-16, 1953 (5), *-Peromyscus leucopus,* Sept. 15, 1953 (3) and *Peromyscus maniculatus,* Oct. 7, 1951, KU 3737. *Douglas Co.*: 5 mi. N, 1 mi. E Lawrence, Univ. Kansas Nat. Hist. Reserv., *Coluber constrictor,* Oct. 5, 1949, KU 3732, *-Crotalus horridus,* Sept. 5, 1949, KU 3731, *-Pituophis catenifer,* Oct. 17, 1950, KU 3701-19 and (7), *-Thamnophis sirtalis,* Aug. 25, 1949, KU 3733, *-Peromyscus maniculatus,* Oct. 20, 1951, KU 3720-30 and (1). *Wallace Co.*: 3 mi. W Sharon Springs, *Peromyscus maniculatus,* July 4, 1949, KU 3738-52 and (1).

DISTRIBUTION OF PARATYPES

Paratypes of the new species and subspecies will be sent to the United States National Museum; the Rocky Mountain Laboratory; the British Museum (Natural History); the South Australian Museum, Adelaide; Dr. G. W. Wharton, University of Maryland; Dr. Charles D. Radford, Manchester, England; the Museum National d'Histoire Naturelle, Paris, France; the Army Medical Service Graduate School, Washington, D. C.; and Dr. J. R. Audy, Institute for Medical Research, Kuala Lumpur, Malaya.

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TABLE I.—Scutal Measurements of *Trombicula gurneyi* and *T. kansasensis*

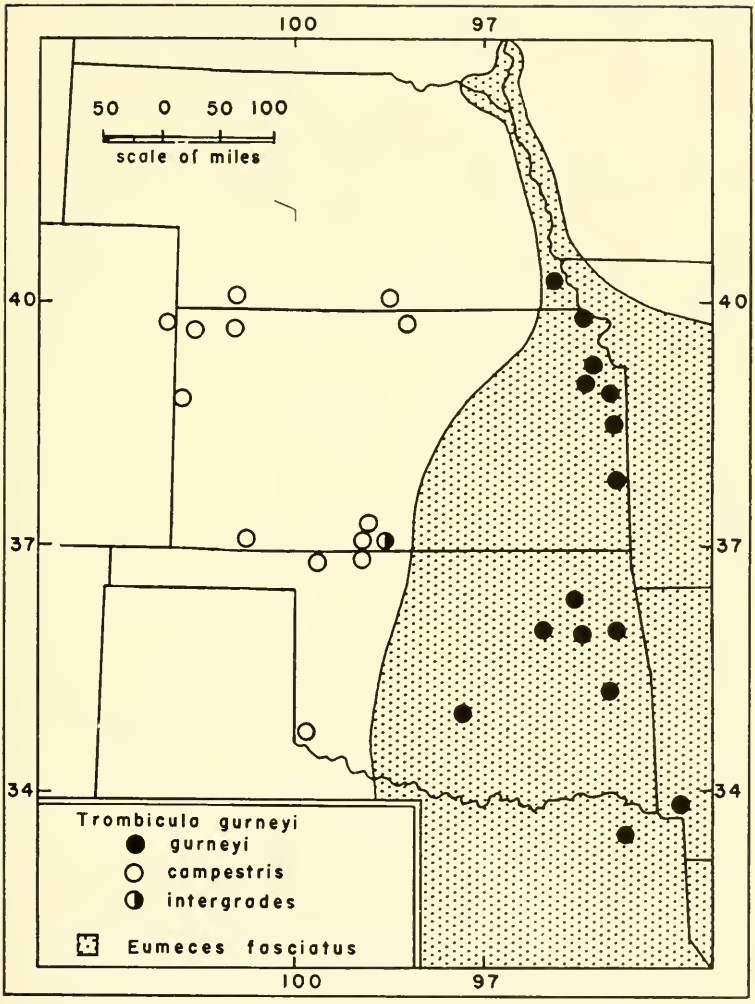
	No.	AW	PW	SB	ASB	PSB	AP	AM	AL	PL	S
Trombicula g. gurneyi											
Cotype	1	59	70	28	21	15	15	.....	20	43	.....
Holotype (*T. hamertoni*)	*	62	70	26.5	21	15.5	14	26.5	23	45	48
Miami County, Kansas	5	61	72	28	22	16	15	28	23	41	48
		59–63	71–75	27–28	21–24	14–19	14–17	26–30	21–24	40–43	45–51
T. g. gurneyi x *campestris*											
Barber County, Kansas	5	60	70	28	21	16	16	31	24	45	51
		58–63	70–71	27–28	21	16–17	16–17	28–35	23–27	43–47	49–53
T. g. campestris											
Rawlins County, Kansas	6	66	76	31	22	16	17	37	26	44	53
(topotypes)	.....	63–70	75–79	30–33	20–23	15–18	16–18	35–38	23–27	42–45	51–55
Barber County, Kansas	3	62	71	30	20	17	16	38	26	43	55
		61–64	70–72	30	20–21	16–18	15–17	36–41	24–28	40–43	53–57
Trombicula kansasensis											
Douglas County, Kansas	6	74	87	38	27	19	20	48	28	50	70
(topotypes)	.....	71–77	77–92	37–40	26–28	17–21	19–22	45–50	27–30	49–51	68–74
Douglas, Barber and Wallace Counties, Kansas	14	71	84	35	25	19	19	46.5	27	49	69
		65–77	75–100	32–40	21–28	17–21	17–22	44–50	25–30	46–52	65–74

* Scutal measurements provided by Radford (*in litt*, 1952) and Evans (*in litt*, 1953, 1954) correcting those previously published (Radford, 1946: 589), *in errore*.

FIGURE 1

Map showing the known localities of *Trombicula gurneyi* Ewing, in the central United States, and the known range of the five-lined skink, *Eumeces fasciatus* (Linnaeus), after Taylor (1935:205).

FIGURE 1


100
97
50 0 50 100
scale of miles
40
37
34
Trombicula gurneyi
gurneyi
campestris
intergrades
Eumeces fasciatus

FIGURES 2-6

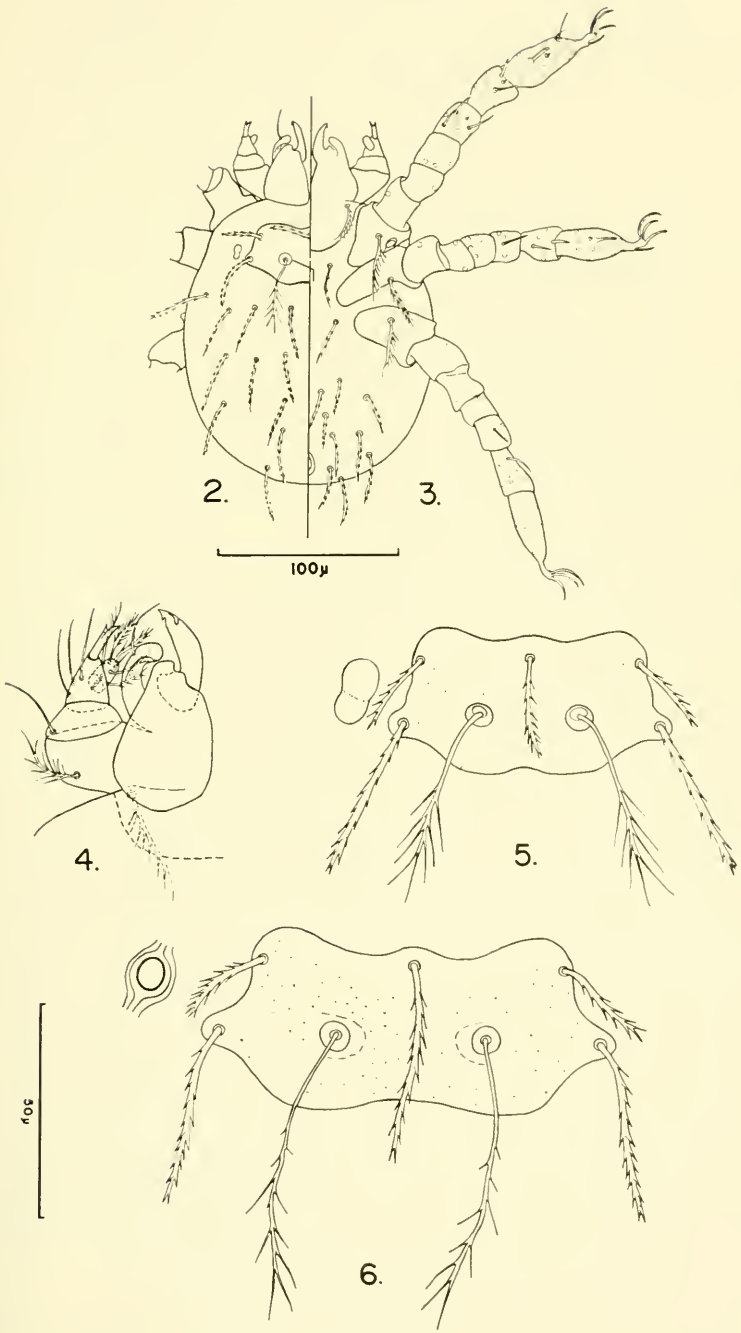
Trombicula gurneyi gurneyi Ewing

FIG. 2. Dorsal aspect of body.
FIG. 3. Ventral aspect of body, showing the nude setae on the legs.
FIG. 4. Gnathosoma.
FIG. 5. Scutum and eyes.

Trombicula kansasensis sp. nov.

FIG. 6. Scutum and eye.

FIGURES 2-6



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Comparison of the Effects of Administration of Propyl– and Iodothiouracil to Pregnant Guinea Pigs [1]

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ABSTRACT. From the differences in the response of the thyroid glands of fetal guinea pigs to propyl- and iodothiouracil administered in approximately equimolar doses to the mother during the last 30 days of pregnancy, it is concluded that, like propylithiouracil, iodothiouracil passes the placental barrier. The goitrogenic activity of iodothiouracil is about one thirteenth that of propylthiouracil.

Both drugs cause an increase in litters with one or more dead offspring, and an increase in fetal mortality. Propylthiouracil was more deleterious than iodothiouracil. Fetal mortality was reduced by administering thyroxine simultaneously with propylthiouracil or by giving the propylthiouracil throughout pregnancy.

It has been reported that, although 5-iodo-2-thiouracil lowers the rate of oxygen consumption in the rat approximately the same amount as thiouracil (Barrett and Gassner, 1951), the iodo- form does not cause significant goiter formation in this species (Barrett, Gassner and Dittmer, 1951; Bradley, 1954). Extreme sensitivity of fetal guinea pigs to goitrogenic agents is indicated by the very large goiters found in offspring of propylthiouracil-treated mothers (Peterson, Webster, Rayner and Young, 1952; Peterson and Young, 1952). It was felt that the goitrogenic activity of iodothiouracil could be better investigated in this more sensitive test animal, provided the drug passed the placenta. Information relating to possible effects of propyl- and iodothiouracil on the outcome of pregnancy would also be gained from such experiments.

1. This investigation was supported in part by research grant RG-3017 from the National Institutes of Health, Public Health Service, and in part by grant 44 from the University of Kansas Research Fund to William C. Young.

2. Research Fellow of the National Institutes of Health, Public Health Service. Present address: Department of anatomy, Washington University School of Medicine, St. Louis, Missouri.

METHODS

Pregnant guinea pigs were treated as follows beginning on the 38th day of gestation: Seven were given 0.1% propylthiouracil[3] and 10 were given 0.15% iodothiouracil[4] in the drinking water. Ten untreated pregnant guinea pigs served as controls. From measurements of the daily water consumption the average drug intake was found to be 35 mg or 206 micromols of propylthiouracil per day, and 70 mg or 276 micromols of iodothiouracil per day.

On the day of delivery the thyroid and pituitary glands of the offspring were removed, dissected free of excess fat, weighed on a torsion balance, and fixed in 0.9% saline solution saturated with mercuric chloride to which formalin was added just before use in the ratio of 1:10. The thyroids of the mothers were also removed and fixed at this time. The thyroid glands were embedded in paraffin, sectioned at 10μ, stained with hematoxylin and eosin, and examined microscopically.

This investigation deals in part with possible effects of treatment with antithyroid drugs on the outcome of pregnancy. In earlier experiments data pertaining to this facet of the problem were accumulated. These data, previously unpublished, are presented here for comparison with the data resulting from the present experiments. The treatments employed are described in detail in previous publications (Peterson, Webster, Rayner and Young, 1952; Peterson and Young, 1952). In the experiments described in the first of these papers the animals received propylthiouracil before mating and throughout pregnancy while in the experiments set forth in the second paper the animals received propylthiouracil alone or in combination with thyroxine during the last 30 days of gestation.

All guinea pigs were from our own stock kept under the following conditions: The temperature of the laboratory was maintained between 70° and 75° F. Food and water were available at all times. The diet consisted of a mixture of oats and rabbit pellets supplemented with alfalfa hay and fresh green vegetables once daily.

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3. The propylthiouracil used in this investigation was supplied by Lederle Laboratories, Pearl River, New York.

4. The iodothiouracil used was supplied by CIBA Pharmaceutical Products Inc., Summit, New Jersey.

RESULTS

The average birth weight was significantly lower than the control value in both treated groups (Tab. 1). The relative thyroid weight of offspring from propylthiouracil-treated mothers was, on the average, 91 times that of the control offspring. In the offspring from iodothiouracil-treated mothers the relative thyroid weight was approximately 7 times that of the controls. The differences between the thyroid weights of offspring from control and treated animals were of the same general magnitude as the above figures when calculated on the basis of absolute weights. The relative pituitary gland weights of the offspring in both treated groups were significantly heavier than the control value. However, these differences were not apparent if one considered the absolute weights.

The thyroid of the untreated female guinea pig at the termination of pregnancy has follicles of variable size lined with a very flat epithelium (Fig. 1). After 30 days of treatment with propyl- or iodothiouracil during pregnancy there was detectable only little stimulation of the maternal thyroid (Figs. 3 and 5). Most of the thyroids from treated mothers could not be distinguished from those of untreated mothers. However, the thyroids of three females in each of the treated groups showed some stimulation. The degree of stimulation was slightly greater in the three iodothiouracil-treated females than in the three propylthiouracil-treated females.

The thyroids of offspring from propylthiouracil-treated mothers showed the extreme stimulation typical of such glands (Fig. 4). The follicles, practically devoid of colloid, were lined with a high columnar epithelium which showed spur formations. The thyroids of offspring from iodothiouracil-treated mothers were made up of large follicles containing colloid (Fig. 6). The epithelium was of variable height, ranging from low cuboidal to columnar types. There was histological evidence of some stimulation in most of the glands from this group, but in none of the glands was the stimulation so great as that caused by propylthiouracil.

Data bearing on the effect of antithyroid drugs on the outcome of pregnancy are summarized in Table 2. There was a percentage increase in the number of litters with one or more dead offspring, and a percentage decrease in the young born alive following propylthiouracil treatment during the last 30 days of pregnancy. This effect was greater with propylthiouracil treatment than with iodothiouracil treatment. Thyroxine administered simultaneously

with propylthiouracil eliminated fetal mortality in the four females so treated. When propylthiouracil was given throughout pregnancy the percent of litters with dead offspring was essentially the same as that of the control group, and the percent of young born alive was only slightly less than the control value. Litter size was not affected by any of the treatments.

DISCUSSION

The use of the fetal guinea pig as an assay animal for the goitrogenic activity of antithyroid drugs is probably a more sensitive test than any yet devised, because the magnitude of the response is so great that goitrogens undetectable in the rat give a measurable response in the fetal guinea pig. In addition the treatment of small numbers of pregnant guinea pigs yields an adequate sample of target organs for statistical analysis. The time necessary for a full response is relatively short, i. e., 30 days. It is obvious that in order to be assayed in this manner, the drug must be able to pass the placental barrier of the guinea pig. It has been demonstrated that propylthiouracil passes the placenta (Peterson and Young, 1952). From the evidence obtained in this study it is judged that iodothiouracil also passes the placenta of the guinea pig and that its goitrogenic action on the fetal thyroid is approximately one-thirteenth that of propylthiouracil.

The effects of these two antithyroid agents on the outcome of pregnancy are not easy to explain. It is apparent that in the dosages employed, both propyl- and iodothiouracil increase fetal mortality. In the case of propylthiouracil at least, this effect can be overcome by simultaneous administration of thyroxine in appropriate amounts. Comparable experiments have not yet been carried out using iodothiouracil. We attribute the fetal mortality observed under short term treatment to a pharmacological reaction in the fetus which can be counteracted by exogenous thyroxine. If this is a pharmacological reaction, why is it not manifested when the antithyroid agent is given throughout pregnancy? No explanation for this enigma is possible with the present data.

SUMMARY AND CONCLUSIONS

From the differences in the response of the thyroid glands of fetal guinea pigs to propyl- and iodothiouracil administered in approximately equimolar doses to the mother during the last 30 days of pregnancy, it is concluded that, like propylthiouracil, iodothiouracil passes the placental barrier. The goitrogenic activity of iodothiouracil is about one thirteenth that of propylthiouracil.

Both drugs cause an increase in litters with one or more dead offspring, and an increase in fetal mortality. Propylthiouracil was more deleterious than iodothiouracil. Fetal mortality was reduced by administering thyroxine simultaneously with propylthiouracil or by giving the propylthiouracil throughout pregnancy.

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TABLE 1.—Effect of Treatment of the Mother on the Weight of the Thyroid and Pituitary Glands of the Newborn Guinea Pig

TREATMENT	Number of mothers	Number of young	Birth weight	Thyroid weight (mg/100 gm)	Pituitary weight (mg/100 gm)
Untreated.....	10	30	96.3±2.8[1] (30)	31.4±1.3[1] (30)	6.3±0.24[1] (29)
Propylthiouracil...	7	22	71.9±4.0* (17)	2853.5±572.6* (13)	7.5±0.44** (8)
Iodothiouracil....	10	29	63.3±3.0* (29)	227.5±35.3* (25)	7.9±0.35* (15)

[1] The ± values are the standard errors of the means. The figures in parentheses are the number of animals on which the averages are based.

* The difference from the control value is significant at the 1% level.

** The difference from the control value is significant at the 2% level.

TABLE 2.—Effect of Antithyroid Drug Administration on the Outcome of Pregnancy

TREATMENT	Previous experiments*				Present experiments			
	Number of mothers	Percent litters with dead young	Number of young	Percent born alive	Number of mothers	Percent litters with dead young	Number of young	Percent born alive
Untreated	44	39.6%	152	79.6%	10	10%	30	90.0%
Propylthiouracil last 30 days of pregnancy	11	90.9%	31	32.3%	7	100%	22	22.7%
Propylthiouracil and thyroxine last 30 days of pregnancy	4	0%	15	100%				
Iodothiouracil last 30 days of pregnancy					10	60%	29	41.4%
Propylthiouracil throughout pregnancy	30	41.2%	92	67.4%				

* Peterson, Webster, Rayner and Young, 1952; Peterson and Young, 1952

PLATE 1

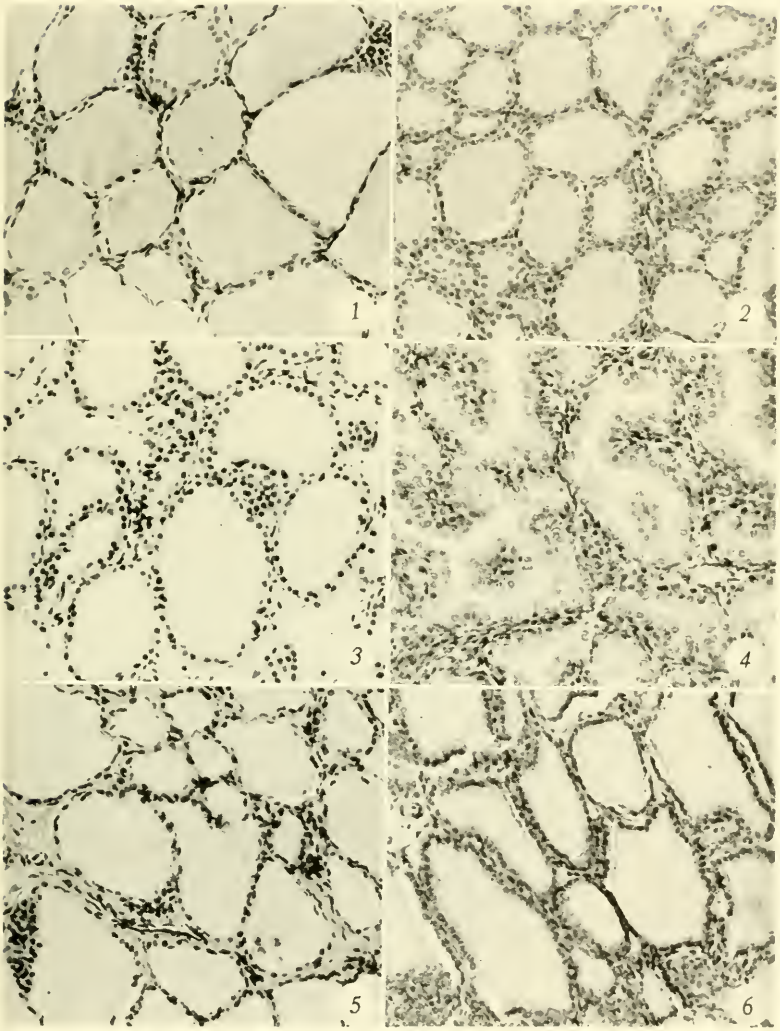

FIG. 1. Thyroid of an untreated control female. × 200.
FIG. 2. Thyroid of an offspring from an untreated control female. × 200.
FIG. 3. Thyroid of a propylthiouracil-treated female. × 200.
FIG. 4. Thyroid of an offspring from a propylthiouracil-treated female. × 200.
FIG. 5. Thyroid of an iodothiouracil-treated female. × 200.
FIG. 6. Thryoid of an offspring from an iodothiouracil-treated female. × 200.

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VOL. XXXVII, PT. I] OCTOBER 15, 1955 [NO. 11

A Taxonomic Revision of the Family Gelastocoridae (Hemiptera)

BY

EDWARD L. TODD *

ABSTRACT.—This paper constitutes a revision of the family Gelastocoridae (Hemiptera). The nature of the paper is primarily taxonomic, but information on the biology of some of the species of the family is included.

Prior to this work, the subfamily Gelastocorinae contained two genera and the subfamily Nerthrinae contained six genera. In this paper there is considered to be but a single genus in each of the two subfamilies. Prior to this work, seventy-one species were recognized in this family. Of this number, fifteen are placed in synonomy, one species reduced to subspecific status, one species renamed, and three varieties or subspecies are raised to specific status. Sixteen new species are described in this paper and all other species available to the worker are redescribed.

The new species are: *Gelastocoris viridis* (Mexico, Guatemala), *Nerthra buenoi* (Brazil), *N. williamsi* (Brazil), *N. corudis* (Guatemala), *N. manni* (Mexico), *N. hungerfordi* (Central America), *N. bracchialis* (Mexico), *N. gurneyi* (Bougainville Island), *N. omani* (Guadacanal Island), *N. nudata* (Australia), *N. macrostyla* (Solomon Islands), *N. robusta* (New Guinea), *N. tasmaniensis* (Tasmania), *N. walkeri* (Australia), *N. sinuosa* (Australia).

Genera placed in the synonomy of *Nerthra* Say are: *Mononyx* Laporte, *Phintias* Stål, *Matinus* Stål, *Peltopterus* Guérin-Méneville, and *Glossoaspis* Blatchley. In the Gelastocorinae, *Montandonius* Melin is placed in the synonomy of *Gelastocoris* Kirkaldy.

Nerthra tenebrosa is the new name used for *Mononyx obscurus* Melin which is a homonym of *Mononyx obscurus* Stål.

Gelastocoris andinus peruensis Melin, *Mononyx amplicollis* var. *ecuadorensis* Melin and *Mononyx fuscipes* var. *rudis* Melin are raised to specific rank.

Gelastocoris variegatus (Guérin-Méneville) is treated in this paper as a subspecies of *G. oculatus* (Fabricius).

The new synonomy at the specific level is as follows: *Gelastocoris cucullatus* Martin, a synonym of *G. hungerfordi* Melin; *G. duplicatus* Martin, a synonym of *G. major* Montandon; *G. californiensis* Melin, a synonym of *G.*

* Currently with Entomological research Branch, Agricultural Research Service, U. S. Department of Agriculture, Washington, D. C.

oculatus oculatus (Fabricius); *G. bergi* DeCarlo, *G. vianai* DeCarlo, *G. bolivianus* DeCarlo and *G. paraguayensis* DeCarlo, synonyms of *G. nebulosus* (Guérin-Méneville); *G. martinezi* DeCarlo, a synonym of *G. fuscus* Martin, *Montandonius willineri* DeCarlo, *M. mansosotoi* DeCarlo and *M. bridarolli* DeCarlo, synonyms of *G. angulatus* (Melin); *Mononyx niger* Melin, a synonym of *N. ranina* (Herrich-Schäffer); *M. stali* Melin, a synonym of *N. grandicollis* (Germar); *M. projectus* Distant, a synonym of *N. indica* (Atkinson); *Glossoaspis brunnea* Blatchley, a synonym of *N. rugosa* (Desjardins).

Including this paper, there are seventy-four species and one subspecies recognized in this family.

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INTRODUCTION

The family Gelastocoridae, as considered in this work, is composed of two subfamilies, each of which has within its limits a single genus. The total number of species is 74, of which 13 belong to the genus *Gelastocoris* and 61 to the genus *Nerthra*. The identification of the species in this family has always been most difficult. This has been due, in part, to the similarity of many species and the extreme variability of color and of certain morphological characters within a single species. On the other hand, the difficulty has, in part, also been due to the inadequacy of many of the original descriptions, especially of the earlier workers, and the lack of comprehensive keys. It has been the aim of the writer to assemble the literature pertaining to the Gelastocoridae; to present the known facts concerning the biology and the ecology of the species of this family; to establish techniques which would facilitate the study of the Gelastocoridae; to evaluate the characters used in the taxonomic study of these insects; to study geographical distribution as an aid to our knowledge of their phylogeny; to determine the phylogenetic relationships between the Gelastocoridae and other cryptocerous Hemiptera; to discover the natural relationships among the species within the family; and finally to present keys which would permit the determination of genera and species of this difficult family. One of the greatest obstacles to the accomplishment of these aims has been the inaccessibility of type specimens. The types, for the most part, are scattered in the various European museums. Limited material available for study, particularly from certain areas of the Eastern Hemisphere, has been another hindrance. Even so, the writer has been able to study what is without question the largest collection of Gelastocoridae ever assembled. In addition to the very large collection in the Francis Huntington Snow Entomological Collection at the University of Kansas, the writer has received, through the efforts of Doctor H. B. Hungerford,

specimens from nearly all the major entomological collections in this country and from some of the collections in Europe.

In this study, it has been necessary to place in synonomy a number of genera, which in my opinion were not based upon sound generic characters. It is unfortunate that it was not currently possible to retain more of the existing generic names, at least as subgenera, but, as it will be explained at another point (see pages 296, 343), many of the characters previously utilized have certainly developed independently in rather distantly related species and therefore do not delimit natural groups. This is particularly true in the subfamily Nerthrinae. Such characters are very useful in the formation of keys, but obviously of considerably less importance in the development of a natural system of classification. It is the hope of the writer that this work will simplify the task of specific determination and especially, that it will stimulate other workers to undertake further studies concerning the taxonomy, biology and ecology of the Gelastocoridae.

ACKNOWLEDGMENTS

The writer wishes to take this opportunity to express his appreciation for the assistance received from various sources during the progress of this study.

To Doctor H. B. Hungerford of the University of Kansas, who suggested this study to me, I am especially grateful. Not only has he generously given his time to the discussion of various problems that occurred from time to time, but also, through his influence specimens were received from most of the major collections in this country and from several European museums. Further, his notes on the specimens in many of the European museums have greatly facilitated many aspects of this investigation.

To Doctor C. D. Michener of the University of Kansas, I am deeply indebted for the encouragement he has given to me and for the consideration he has given to the many questions of procedure and taxonomy.

To the others at the University of Kansas, and especially to Doctors Kathleen Doering and R. H. Beamer, I am sincerely appreciative for their willingness to give assistance at all times.

Thanks are due to Doctor O. Lundblad of the Museum of Stockholm, Stockholm, Sweden, through whose kindness the writer was able to study those types of Douglas Melin which are located in that museum; to Doctor R. L. Usinger of the University of California, who not only sent material from his personal collection,

but also made a number of comparisons between drawings sent by this writer and types located in the British Museum in London, England; and to Doctor Eugene Seguy of the Museum of Paris, for his comparison of a specimen with a type located in that Institution and for sending a paratype of one of the species I had not been able to study.

I would also like to thank the curators of the various museums and collections who have provided specimens for this study. As it has been necessary to abbreviate the names of these institutions in the distributional data of the descriptions in this work, a list of these institutions and the abbreviations used is given at this point.

United States National Museum at Washington, D. C., (USNM); American Museum of Natural History at New York City, N. Y., (AMNH); Museum of Comparative Zoology at Harvard University, Cambridge, Mass., (MCZH); California Academy of Science at San Francisco, California, (CAS); J. C. Lutz Collection, Philadelphia, Pennsylvania, (J. C. Lutz Coll.); Carnegie Museum at Pittsburgh, Pennsylvania, (Car. Mus.); Museum of Prague, Prague, Czechoslovakia, (Mus. Prague); University of Michigan Collection at Ann Arbor, Michigan, (Mich. Coll.); Purdue University Collection at Lafayette, Indiana, (Purdue Coll.); British Museum (Natural History), London, England and Rijksmuseum van Natuurtijke Historie, Lieden, Netherlands. All specimens not indicated by one of the above abbreviations or unless otherwise stated are located in the Francis Huntington Snow Entomological Collection at the University of Kansas.

BIOLOGY AND ECOLOGY

Little is known concerning the biology of the Gelastocoridae. The life history of only one species, *Gelastocoris oculatus* (Fabricius), is known to any extent. Doctor H. B. Hungerford's study of this species (Univ. Kansas Sci. Bull., 1922, vol. 14, pp. 145-171.) has shown that the oval eggs are deposited in sand with the cephalic end uppermost. The egg, which is white when dry and amber or ferruginous when moistened, blends perfectly with the sand. One female probably deposits as many as 200 eggs during a season. Doctor Hungerford recovered 192 nymphs and eggs from one female. The number of eggs laid per day may vary from 1 to 13. The incubation period is from 12 to 15 days. There are five nymphal instars. The total developmental period is from 60 to 100 days. In the laboratory, mating occurred almost daily from May to November, but it is not known whether this is true when

the insects are in their natural habitat. Millspaugh (Field and Laboratory, 1939, vol. 7, No. 2, pp. 82-83.) suggests that *G. cucullatus* Martin (=*G. hungerfordi* Melin) has a definite period during which mating is more commonly observed than at other times during the season. The exact number of generations of *G. oculatus* (Fabricius) is unknown, but probably varies from one in the extreme northern part of its range to several in the southern part of its range. It is not recorded in the literature how *G. oculatus* (Fabricius) and other species pass the winter in regions where this season is unfavorable to an active mode of life. It is, however, fairly certain that they over-winter in the adult stage; undoubtedly they seek out protected places to pass the winter. In addition to Hungerford's study of *G. oculatus* (Fabricius), Kevan (Proc. R. Ent. Soc. London, ser. A, vol. 17, 1942, pp. 109-110.) has studied the life history of *Nerthra nepaeformis* (Fabricius) in Trinidad. Although he was unable to rear these insects through their complete life cycle, he was successful in rearing captured fifth instar nymphs through to adults. Adults were observed mating, but no eggs were obtained. Except for captured nymphs of various instars, which cannot be identified in the light of present knowledge, nothing is known concerning the life cycles of the other species of this family.

While all the species of the Gelastocorinae are found on the mud or sand banks of streams, ponds, etc., this is apparently not entirely true for all the species of the Nerthrinae. Melin (Zoologia Bidrag Fran Uppsala, 1929 *, Band 12, p. 194.) wrote: "Of the three specimens of *M. bipunctatus* I collected in Peru, the male lived in a decomposed trunk in a 'chacra' of bananas, the female on the ground in the forest amongst dry leaves, and the larva on a trunk in a clearing." Kevan (*l. c.*) states: "*M. nepaeformis* has been taken commonly, both by writer, and by Dr. H. B. Hynes, in a small banana plantation attached to the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, during both wet and the dry seasons of 1941-1942. There is neither standing nor running water anywhere in the vicinity of this plantation, and, in the dry season, the ground becomes parched and dry. The insects are most readily found under debris, such as heaps of dry grass or old pawpaw stumps, and seem to spend much of their time burrowing in the soil, where they are common also, though less easily detected, while nymphal exuviae have often been found underground. In the laboratory, too, they will readily burrow in moderately loose soil.

* See page 288.

All their time, however, is not spent in this manner, for the writer has swept the species from low vegetation on to which it had climbed, presumably in search of prey." According to Torre-Bueno (Ent. News, 1906, vol. 17, p. 54.), Biolley found a specimen of *N. fuscipes* (Guérin-Méneville) in a rotten log in Costa Rica in December of 1904. Maxwell-Lefroy (Indian Insect Life, Calcutta, 1909, p. 709.) writing about *N. indica* (Atkinson) states: ". . . it is found on grass paths, on the soil and under stones, as well as on hard roads; it is not aquatic and is possibly predaceous on small insects." In contrast to the above, La Rivers (Wasmann Journ. of Biol., vol. 11, no. 1, 1953, pp. 83-84.) reports some very interesting observations on the habitat of *Mononyx fuscipes* Guérin-Méneville (probably *N. martini* Todd). In discussing the capture of specimens in Inyo County, California, he states: "Most of the specimens were immatures taken at or near the surface of the water. They readily crawl beneath the water surface along plant stems while searching for prey." Concerning two collections from Clark County, Nevada, he reports: "The first Nevada record obtained, at Warm Springs, resulted in some half-a-dozen mature and as many immature specimens, taken, for the most part, from their hiding places on the undersurfaces of pieces of wood partially submerged in a marshy tract of quiet, shallow, warm water (83° F, pH 7.3). The bottom was fine, black silt. Most of the specimens were clinging to the wood just below the water surface." and "The Ash Meadows specimens were taken from the undersurfaces of rocks bathed by swiftly flowing 90° F. water (pH 7.3) and, like the Clark County individuals, were not common; . . ." The observations of La Rivers brings to mind a comment by Doctor R. H. Beamer pertaining to the capture of a specimen of *Nerthra rugosa* (Desjardins). Doctor Beamer stated that the specimen was first observed near some debris adjacent to the surf on Matecumba Key, Florida, and that when it was disturbed it jumped into the water among some floating vegetation and that it clung there to a submerged plant until collected. This may have been entirely accidental, but is of interest in light of La Rivers' observations.

Apparently all species are predatory as evidenced by the raptorial front legs. Their prey must consist of small insects and especially the larvae of those insects which are found in association with the Gelastocoridae. Kevan (*l. c.*) has reported that in the laboratory *N. nepaeformis* (Fabricius) preferred termites as food, while small moths and beetles were not received with favor.

In regard to the burrowing habit of certain species, an observation of Doctor H. B. Hungerford on *G. oculatus* (Fabricius) is of interest. Doctor Hungerford states that he has seen broad, sandy, barren flats where toad bugs lived become inundated by rapid currents of water for a few hours; nevertheless, when the water receded and the sun came again, the toad bugs were there as before. Since there was neither vegetation nor sizable stones for their anchorage, he supposes that they "dug in". Although *G. oculatus* (Fabricius) has well-developed wings, the writer has never seen a specimen fly. When they are disturbed, they will either hop away or crouch down against the mud or sand, apparently depending upon their coloration to protect them from detection. The facts that they burrow and that they apparently do not often fly perhaps will explain, in part, the reduction of the membrane of the hemelytra and of the entire hind wing in some species. The fact that some species have the hemelytra united may be due to the above habits. At least, it is the opinion of the writer that any mutation toward the brachypterous condition would not be harmful as far as their habits are concerned.

PHYLOGENY

Because of the habitat and the structure of the body, the family Gelastocoridae has usually been considered as representing an intermediate group in the progression from a terrestrial to an aquatic mode of life. Whether this family represents an independent line of development toward the semiaquatic mode of life or whether they have arisen from a common ancestor with existant aquatic forms, for example the Naucoridae, is not clear. The morphological similarity between the subfamily Nerthrinae and the Naucoridae is, in some respects very great. However, Doctor R. L. Usinger, in a discussion with the writer, pointed out that 3rd instar nymphs of Naucoridae possess abdominal scent glands while the nymphs of Nerthrinae apparently lack such glands. He considers that this is a very fundamental difference. He further stated that he does not believe that the absence of scent glands in the Nerthrinae could be due to a reduction or a loss. The similarities of the eggs, mouthparts, grasping forelegs, antennae, and abdominal segmentation must therefore be considered as parallel developments. On the basis of our present knowledge we must conclude that the Gelastocoridae represent an independent line of development toward the semiaquatic mode of life. It has generally been assumed that the approach was from terrestrial

forms to semiaquatic forms to truely aquatic forms, however, in the Gelastocoridae the immediate ancestors may have lived entirely in the aquatic (semiaquatic) state and our present forms may represent departure from the water to the terrestrial mode of life. It is also possible that the Nerthrinae alone had aquatic ancestors and the Gelastocorinae did not enter the water. The hidden antennae of the Gelastocoridae could have been so developed either as an adaptation to an aquatic mode of life or as an adaptation to the burrowing habit. Thus morphological evidence based upon the antennae could be used to support either type of progression. At the present time only one species has been found living in the water. The writer has not seen all the specimens collected by La Rivers, but two males from the Warm Springs, Clark Co., Nevada series collected by La Rivers and Johnson are *Nerthra martini* Todd. The species has also been collected in a terrestrial habitat. On the other hand species of Nerthra have been found in situations quite remote from water in India, Perú, and Trinidad. The normal habitat of the majority of the species of the Nerthrinae and of all the Gelastocorinae would seem to be the moist terrestrial margins of streams and other bodies of water. It seems best to consider the specimens collected by La Rivers as representing the first record of a species *entering* the water rather than the last species *leaving* the water. This conclusion is supported by the less specialized condition of the Gelastocorinae. In the opinion of the writer, based on a comparative study of the legs, mouthparts, abdominal segmentation and the male genitalia, the Gelastocorinae is the more primitive of the two subfamilies. Normally we would expect to find the more primitive forms, not the more specialized forms, occupying a habitat most closely resembling the habitat of their ancestors.

Fossil evidence would undoubtedly be helpful in the solution of the problem of direction of progression of habitat and also such evidence would certainly aid in the explanation of the current distribution of the species of this family. Unfortunately fossils of the Gelastocoridae are unknown. *Limnochares antiquus* Heyden which was described as a mite and *Necygonus rotundatus* Scudder (U. S. Geological Survey of the Territories, 1890, pp. 347-348, pl. 7 fig. 8.) have been placed in the family by Bertkau and by Scudder. In the opinion of the writer they do not belong to the Gelastocoridae. Fossils of aquatic hemiptera such as Nepidae, Naucoridae, Notonectidae, etc. are known and some date back to Triassic and Jurassic times. The absence of gelastocorid fossils may be an indication that

ancient members of this family were terrestrial and that they did not inhabit areas which were immediately adjacent to water. It is true, however, that many of the fossils of aquatic insects are from European deposits and gelastocorids do not occur in Europe at the present time and they may never have occurred there. Since the Gelastocorinae are at present known only from the Western Hemisphere, we must assume either that they originated here or that they once had a more widespread distribution. If the first assumption is correct and the Gelastocoridae are the more primitive, then the Nerthrinae must also have originated in the Western Hemisphere. If this is true, then the spread of the species could have been by way of Alaska into Asia and then toward Australia and Africa. If, on the other hand, the Gelastocorinae had a more widespread distribution in the past, then the spread of Nerthrinae could have been in the reverse direction in which event, *Nerthra grandicollis* (Germar) could represent a relict species. The species of Africa, China, India and Sumatra exhibit characteristics in common with both the Australian species and with the species from the Western Hemisphere. This could be used as evidence for either direction of distributional spread. In the absence of fossil evidence, it is not possible to conclude at this time whether the distributional spread was as suggested above. Perhaps future biological and morphological studies will help solve this problem.

TAXONOMY OF THE GELASTOCORIDAE

Previous Studies of the Gelastocoridae

Before consideration of characteristics which have been used by the writer, it seems best to present a brief review of the literature, placing special emphasis upon the principal workers and upon the dates and the authors of the original generic and subgeneric descriptions.

In 1802, Latreille established the genus *Galgulus* for *Naucoris oculata* Fabricius, 1798. Billberg, 1820, first used the name Galgulidae (Galgulides). For nearly a century thereafter the family was known by this name. Thomas Say, 1832, described a new genus and species which he named *Nerthra stygica*. He apparently was separating it from *Naucoris* and did not mention the Galgulidae. One year later, in 1833,* Laporte described the genus *Mononyx* with *Naucoris raptoria* Fabricius, 1803, as the type of the genus. He placed this genus in the family Galgulidae. *Nerthra nepaeformis*

* Harris, H. M., Pan-Pacific Entomologist, vol. 18, no. 4, 1942, pp. 161-162, shows that De Laporte's paper did not appear in 1832 as usually given.

(Fabricius), which was described in 1775 as *Naucoris nepaeformis,* was not included in this family until 1868. During 1843 and 1844, Guérin-Méneville proposed, as a subgenus of *Mononyx*, the name *Peltopterus.* He based this subgenus upon *Naucoris rugosa* Desjardins. The genera *Phintius, Matinus* and *Scylaecus* were erected in 1861 by Stål for *Mononyx grandicollis* Germar, *Monoyx alaticollis* Stål and *Galgulus macrothorax* Montrouzier respectively. The generic names *Phintius* and *Scylaecus* of Stål were placed in the synonomy of *Mononyx* and *Peltopterus* by Montandon in 1899. The latter author was the first worker to present a detailed species key. It included seventeen species and was published in 1899 (Bull. Soc. Sci. de Bucarest-Roumanie, an. VIII, nos. 4 & 5, pp. 392-410.). Furthermore, in 1900 (*ibid.*, an. VIII, no. 6, pp. 1-9.) he presented a key to five species of *Matinus.* This worker also described a dozen or more new species in this family during the years 1895 to 1914. Duméril (Mem. Acad. Sci. l'Inst. Imp. France, 1860, tom. XXXI, 2nd partie, p. 1040.) was the first to recognize that *Galgulus* Fabricius was preoccupied by *Galgulus* Pliny a genus of birds. It was not until 1897 that the situation was altered when Kirkaldy (Entomologist, 1897, vol. 30, p. 258.) renamed the genus *Gelastocoris.* In the preparation of the Biologia Centrali-Americana, Rhynchota Heteroptera, vol. 2, Champion used the manuscript names of Montandon for two new species and he attempted to credit these species to Montandon, however, the fact remains that Champion published these names with his own descriptions and Montandon in 1910, credited *G. vicinus* to Champion.

More recently, Blatchley (Ent. News, 1926, Vol. 36, pp. 49-52.) described what he believed to be a new genus and species, *Glossoaspis brunnea.* Since the specimens on which this name was founded were from Florida, Blatchley understandably did not consider that they might be the same as a species from the Eastern Hemisphere. A specimen from Pearl Island on the Pacific side of Panamá and the description of *Naucoris rugosa* Desjardins made the present writer suspicious. A specimen from Florida was sent to Doctor Eugene Seguy at the Paris Museum and a comparison of this specimen with one of the cotypes of *N. rugosa* Desj. has shown that the two are identical. In the process of identification of specimens collected in northern South America, Douglas Melin (Zool. Bidr. Fran Uppsala, 1929 *, Band 12, pp. 151-194.) undertook

* All sources list this date as 1930, however, Melin's paper was printed separately in December, 1928 and Dr. H. B. Hungerford has a copy which was mailed to him by the author on February 1, 1929.

a revision of the Gelastocoridae of the Western Hemisphere. The results were: 1 new genus, *Montandonius*, 17 new species and 3 new subspecies. His keys, which are based entirely upon external characters, are fairly good and will permit the identification of a majority of the species. In this work Melin refuses to accept the rule of priority, but accepts as the author of the species, the first worker whose description Melin considered sufficient to identify the species. For two new species of *Mononyx*, he used the names *bipunctatus* and *obscurus*. Since both names had previously been used in the genus, his names are homonyms and it has been necessary to rename these species. Kevan (Ann. & Mag. Nat. Hist., ser. 11, vol. 14, 1948, p. 813.) has used the name *Mononyx terrestris* for *Mononyx bipunctatus* Melin. The other species is renamed in this work. At the suggestion of Doctor H. B. Hungerford, Martin (Univ. Kansas Sci. Bull., 1928 *, vol. 18, no. 4, pp. 351-369) made an exploratory survey of the genus *Gelastocoris* and was the first to use male genitalia for the identification of the species. He further discussed the value of the other characters for the identification of the species of this genus. In the paper he described three new species, but he did not make a key to the genus.

TAXONOMIC VALUE OF CERTAIN CHARACTERS

In this study, characters which were used by earlier workers and a number of other characters were examined to determine their value in the identification of species of Gelastocoridae.

Color, which was used almost entirely in the descriptions of earlier workers, has been found to be too variable to be of much value. In a few species the color of certain structures may be characteristic. Such a case is seen in the white tubercles on the frons of *Nerthra tuberculata* (Montandon). It is the opinion of the writer that coloration should not be relied upon alone and that other characters should be used whenever possible.

Size, alone, is not of specific value, except when used with other characters.

In the Nerthrinae, the tubercles of the head have been studied. The tubercles are variable to some extent, but are of value in separating the species into groups. Complete absence of these tubercles may be used and also the number and position of the tubercles may be of value. However, this character should not be relied

* The actual publication date of this paper was in 1929, probably sometime in the period of June to August.

upon alone, because these tubercles are rather variable within some species and may be nearly obsolete in species normally having prominent tubercles.

The apical margin of the head is more or less rounded and similar for most of the species of *Gelastocoris*, however, *G. angulatus* (Melin) usually has the apical margin slightly concave.

The antennae, while somewhat different in the two subfamilies, are not characteristic for a species. They are difficult to study and are nearly identical for all the species of each group.

In the past, the presence of ocelli has been one of the key characters in the separation of this family from the Naucoridae, however, I have found that six species lack ocelli. These six species belong to three rather distantly related groups of the Nerthrinae and undoubtedly ocelli have been lost independently. Although the absence of ocelli does not show a phylogenetic relationship, the presence or absence of ocelli is a useful key character and has been so used by the writer.

The shape of the pronotum, especially at the lateral margin, although slightly variable, seems to be constant for most species. In some species, on the other hand, the degree of variation is quite great and some specimens even show a remarkable difference in the two sides. Also the general shape for many species, within both subfamilies, is more or less similar. One species, *G. angulatus* (Melin), has 6 to 8 distinct, short, longitudinal carinae on the posterior portion of the pronotum. These carinae are lacking in the other species of this genus.

The scutellum, while it differs some between the two subfamilies and to some extent in some of the species of each, is not considered to be of much value in determination of species. In what was formerly the subgenus *Peltopterus*, the scutellum is somewhat smaller than in the other Nerthrinae, but as reduction in size of scutellum follows loss of normal flight wings, this is not considered important and certainly the difference is not sufficient for generic or subgeneric consideration. Furthermore, most specimens are pinned through the scutellum, which makes it difficult to study this structure.

The hemelytra may vary in length for the different species and may be of some value. Reduction of the membrane occurs in both subfamilies and in the Nerthrinae the hemelytra may be entirely coriaceous and separate or fused together. These characters are of value in the identification of species, but as with the absence of

ocelli, have arisen independently and do not imply a close phylogenetic relationship. The embolium exhibits characters that are specific. A few species show a strongly dilated lateral margin. This is considered as a generic characteristic by Melin. The shape of the lateral margin of the embolium of the other species is of some value when used with other characters.

Bristles found on different parts of the insects, especially in Nerthrinae, may prove to be of value upon further investigation. This writer has used bristles, along with other characters, to identify several species. The bristles tend to form groups on the tubercles of the scutellum and upon the hemelytra and they vary in both size and shape for a given species. Also, they are too frequently covered by the encrustation or are rubbed off to be a character of positive identification in most species.

In the genus *Gelastocoris*, some of the granulations, especially upon the hemelytra, may be enlarged and blisterlike or more elevated and peglike. Both may be used with other characters in the identification of species. The blisterlike granules are somewhat variable in number and size within a species, but can be used to help separate a few species.

The legs of *Gelastocoris* are all more or less the same for the different species. In a few species, the legs, especially the hind pair, are a little longer in proportion to the length of the body, but the difference was not great enough to be used. The size and shape of the anterior dilation of the front femora will separate two species in the Nerthrinae from the other species, but the femora of the others are so similar as to be of no value. The trochanters were studied and in particular small tubercles on the apices were examined, but these were found to be too variable within a species to be of value. Proportions of the intermediate and hind legs were checked and results showed them to be more or less the same for all species. Spines on the legs are not characteristic of a species.

The mesosternal elevation was used by Montandon in identification of some of the species of Nerthrinae from the Eastern Hemisphere. This structure is fairly variable within a species and in the opinion of the writer should only be used with other characters, if at all, and only when there is no possibility of confusion with another species, *i. e. N. grandicollis* (Germar). It is difficult to study because it is so often covered by the fore and intermediate legs and commonly destroyed by the insect pin passing through or close to it.

The shape and size of the abdominal segments of the male are relatively constant for a species and of specific value in some cases. In the Nerthrinae, the seventh ventral abdominal segment of the females from the Western Hemisphere, Asia and Africa have the posterior margin deeply emarginate and possess elevations and depressions or both, which are characteristic for the species. The females from the Australian region and Pacific Islands have the seventh ventral abdominal segment more or less projecting posteriorly and covering the ovipositors.

The male genitalia were examined and found to be very characteristic for a species. They should be used as a final check when males are available to the worker. The ovipositors of the females were examined and are of some value when used with other characters and in a few instances are in themselves sufficient to identify species. The ovipositors of some of the species are spined, but the number and position of the spines was found to be too variable to be of value as specific characters.

Various proportions of different parts of the insects were compared and with a few exceptions were practically the same for most of the species in each of the two subfamilies.

TECHNIQUES

In the measurement of the length of the specimens, the distance from the anterior margin of the eyes to the posterior end of the abdomen or to the apices of the hemelytra, whichever was the greater, was used. In the measurement of the width of specimens, both the greatest width of pronotum and width of the abdomen at a level with the apex of the scutellum were recorded. In the males of Nerthrinae, the distance between the caudolateral angles of the sixth ventral abdominal segment was compared with one-half the width of the posterior margin of the fourth ventral abdominal segment. The right side of the fourth segment is used and the distance is measured from the median notch along the posterior margin to the caudolateral angle of this segment. For all other measurements the greatest width or length was used, unless otherwise stated.

The technique for extracting the male genitalia is as follows: The male is determined by the structure of the ventral abdominal segments, the labels may then be pushed down to about one fourth of an inch from the point of the pin and the specimen then immersed in 5% alcohol with the labels resting on the outside of the lip of the relaxing dish, holding the specimen in place.

In this manner a fairly large number of specimens may be relaxed at a time, the number depending upon the speed at which the worker can extract the genitalia. The length of time required for relaxation will vary with the size, the age of the specimens and to some degree, the extent to which the specimens are covered by encrustations. Approximately 15 to 20 minutes is sufficient for *Gelastocoris,* while *Nerthra,* especially the larger species require a longer period. The process can be speeded by using a warm relaxing fluid, but the writer has found that the number of specimens that could be handled at one time must be reduced or the specimens may become too relaxed. This makes extraction of the genitalia more difficult in that the last few segments may tear off in the attempt to remove the genital capsule, unless extreme care is taken in the dissection. A special relaxing fluid (Alcohol 75%, 106 cc.; Distilled water, 98 cc.; Benzol, 14 cc.; Ethyl acetate, 38 cc.) may be used in place of 5% alcohol. When the specimen is sufficiently relaxed, that is to say, when it is relaxed enough to prevent breakage yet stiff enough so that the abdominal segments may be moved only by applying considerable pressure, the genitalia may be extracted. From this point the technique varies according to the subfamily being studied. For the Gelastocorinae, the procedure is as follows: holding the specimen in one hand between the thumb and one finger, insert a small dissecting needle a short distance into the left side of the aperture of the posterior end of the abdomen. Then pushing to the right with the point of the dissecting needle and pulling the needle out at the same time the genital capsule will be extracted. The genitalia may then be turned a quarter of a turn counterclockwise, in this position the genitalia will "lock" against the membrane of the hemelytra and will be exposed at the end of the abdomen, where they are available for study at any time. Occasionally, in old specimens or in specimens which are not completely relaxed, the membranes and the muscles which hold the genital capsule to the preceding segment may break causing the genitalia to become completely separated from the specimen. In such cases, the genital capsule may be placed in a small vial (4 x 10 mm.) in a small amount of glycerin. These vials may be kept with the specimen by running the pin through the cork. When such a procedure is used, it is advisable to run the pin through the cork at a slant and also to use as little glycerin as is necessary to cover the genital capsule. The procedure for the extraction of the genitalia of the Nerthrinae is as follows:

if the entire right clasper is to be studied it is necessary to remove the last two abdominal segments. This portion of the insect is then placed in a drop of glycerin on a slide, where the clasper is removed by breaking the segments longitudinally, and cutting the strong muscles at the base of the clasper. It is unfortunate that it is necessary to destroy these segments, but no other manner could be found for removing the entire clasper. An effort was made to remove the clasper from the specimen without removal of the eighth abdominal segment. It was found, however, that the ninth segment could not be removed separately in most species and that the danger of breaking the clasper was great when such a procedure was attempted. A better procedure and one completely satisfactory for identification is as follows: After relaxation, with a dissecting needle, gently pull the segments to the rear and to the left of the insect until the clasper is clear of the abdomen. Then allow the segments to pull back to their normal position, but direct the clasper with the needle to the ventral side of the abdomen. It will remain in this position and can be studied readily by simply inverting the specimen.

All the drawings of the complete right claspers of the Nerthrinae were made so that the worker will see the ventral surface of the clasper. In this manner comparison may be made with the drawing when the latter method of extracting the clasper is used. In order to make such a comparison, the specimen should be tilted slightly so that the last two segments will be horizontal, thus assuring a true ventral view of the clasper. In emphasizing the value of the second procedure of extraction of the claspers of Nerthrinae, it may be pointed out that the most distinctive part of the clasper in almost all species is the apical half, which ordinarily is fully visible when this procedure is used.

As has been mentioned previously, many specimens, especially in the Nerthrinae, may be covered with an encrustation of mud or other debris. It often becomes necessary therefore, to remove this encrustation, in order to study certain structures. In the past this has been a difficult task, which required much brushing of completely relaxed specimens. Recently, Nelson (Coleopterist's Bull., 1949, vol. 3, no. 6, pp. 89-92.), has discovered a method of removing the encrustations from specimens of the family Elmidae (Coleoptera). This method is satisfactory for cleaning Gelastocorinae and may be used for the Nerthrinae. For insects collected dry or in alcohol, or those which have been pinned in the uncleaned condition, the procedure is as follows:

place the specimen in 5 to 10% acetic acid for 20 to 30 minutes. Then put the specimen in a dish of warm tap water, a Syracuse dish is satisfactory for small species, then add a pinch of trisodium-phosphate, known commercially as "T. S. P." The length of time the specimen is left in this solution varies with the degree of encrustation. When the encrustation has become loosened, it is removed from the specimen by means of a brush with short stiff bristles. Such a brush can be made by taking a small inexpensive paint brush and cutting the bristles down to a length of about 1 mm. and then bending the metal tip inwardly to crowd the bristles together and thus making the brush stiffer. When collecting specimens, if they are placed in Pampel's Fluid, they may be cleaned amazingly well when subjected to 20 or 30 minutes in T. S. P. Pampel's Fluid is composed of the following materials: Distilled water, 30 parts; 95% Ethyl alcohol, 15 parts; Glacial acetic acid, 4 parts; Formaldehyde (40%), 6 parts.

Family Characteristics

Squat, medium sized bugs, head triangular in front view, fitting into concavity between the anterior angles of the pronotum. Rostrum four-segmented. Eyes large, reniform and projecting dorsolaterad. Ocelli usually present. Antennae short, four-segmented, inserted beneath the eyes and hidden between the head and prothorax. Pronotum large, much wider than the head, disk elevated. Scutellum, usually rather large, triangular and elevated. Hemelytra with clavus, corium, embolium and membrane, or with membrane reduced or entirely lacking and in a few species with the hemelytra united. Anterior legs raptorial. Abdominal segments of the male more or less asymmetrical. The nymphs of the species of the entire family possess ocelli as far as is known. This family may be separated from the Ochteridae and Saldidae by the hidden antennae and from the Naucoridae by presence of ocelli in most cases and by the fact that the head is not flattened dorsoventrally.

Key to the Subfamilies and Genera of Gelastocoridae

A. Fore tarsus not fused to tibia, articulate; two well-developed tarsal claws on foreleg in adult; rostrum arising from apex of head, stout, recurved posteriorly ..... (Gelastocorinae) *Gelastocoris* Kirkaldy.

AA. Fore tarsus fused to tibia, not articulate; one well-developed tarsal claw on foreleg in adult; rostrum appearing to arise on ventral surface of head, slender, projecting anteriorly or ventrally ..... (Nerthrinae) *Nerthra* Say.

GELASTOCORINAE Champion

Gelastocorids with the rostrum arising from apex of head, stout, recurved posteriorly. Anterior leg with a single, articulate, tarsal segment which bears two well-developed tarsal claws. Ninth ventral abdominal segment of the male completely invaginated within the body cavity, not visible externally. The male genitalia with posterior process (keel) and right clasper greatly modified, the two structures guiding the simple, tubular aedaegus; left clasper small, simple. Ventrally the abdominal segments of female nearly symmetrical.

The Genus *Gelastocoris* Kirkaldy

(Type of Genus, *Naucoris oculata* Fabricius)

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Small to medium sized bugs, extremely variable in color, but usually more or less variegated. Rostrum arising from apex of head, stout, recurved posteriorly. Anterior leg with a single, articulate, tarsal segment which bears two well-developed tarsal claws. Ocelli present, though rather small in some species. Ninth ventral abdominal segment of the male completely invaginated within the body cavity, not visible externally, the posterior process (keel) and right clasper greatly modified, left clasper small, simple. Ventral abdominal segments of female nearly symmetrical, occasionally with the incision of the posterior margin of the last segment bent to the left of the specimen.

KEY TO THE SPECIES OF GELASTOCORIS*

1.	Basal portion of pronotum with 6 to 8 longitudinal carinae ... *G. angulatus* (Melin)	p.	339
	Basal portion of pronotum lacking carinae ...		2
2. (1)	Lateral margin of pronotum straight or nearly so ...		3
	Lateral margin of pronotum notched ...		4
3. (2)	Lateral angle of pronotum projecting beyond base of embolium, not bent ventrad, connexivum quite visible ... *G. bufo* (Herrich-Schäffer)	p.	322
	Lateral margin of pronotum not or scarcely projecting beyond base of embolium, bent ventrad, connexivum completely or nearly covered by hemelytra ... *G. rotundatus* Champion	p.	314

* *Gelastocoris apurecnsis* Melin is not included. (See page 342.)

4. (2) Membrane of hemelytron reduced, its length subequal to or less than the width of hind femur 5
Membrane of hemelytron well developed, its length usually about twice or more the width of the hind femur 8
5. (4) Pan of male genitalia bilobed ..... *G. major* Montandon p. 327
Pan of male genitalia not bilobed 6
6. (5) Pan wider than long, more or less rounded 7
Pan not wider than long, rather elongate ..... *G. peruensis* Melin p. 329
7. (6) Tumescence of right clasper adnate to base of clasper; keel hook very long and recurved, extending completely back across base of pan ..... *G. nebulosus* (Guérin-Méneville) p. 331
Tumescence of right clasper not adnate to base of clasper; keel hook not recurved back over pan .. *G. viridis* n. sp. p. 338
8. (4) Tumescence of right clasper adnate to base of clasper; keel hook recurved completely back over base of pan ..... *G. nebulosus* (Guérin-Méneville) p. 331
Tumescence of right clasper not adnate to base of clasper, keel hook not recurved completely back over base of pan .. 9
9. (8) Pan of male genitalia very thin, elongate, narrow and twisted apically, turned completely over *G. amazonensis* Melin p. 325
Pan of male genitalia not as above, usually thick, when thin, not elongate or twisted completely over 10
10. (9) Keel hood located to the right side of the keel ..... *G. fuscus* Martin p. 336
Keel hood, not as above, located either to the left side of the keel or covering the entire apex 11
11. (10) Fringe of keel hood nearly transverse, simply concave; secondary keel hood not prominent 12
Fringe of keel hood bent toward apex at middle, then obliquely concave to right margin of apex of keel; secondary keel hood prominent *G. hungerfordi* Melin p. 316
12. (11) Pan rather flattened, wider than long, in an oblique plane in relation to the horizontal plane of the genital capsule ..... *G. vicinus* Champion p. 319
Pan more or less thickened, elongate, not in a distinct oblique plane in relation to the horizontal plane of the genital capsule 13
13. (12) Posterior portion of lateral margin of pronotum usually extending more or less posterolaterad toward lateral angle; color quite variable ..... *G. oculatus* (Fabricius) p. 298
Posterior portion of lateral margin of pronotum transverse or nearly so; white coloration more abundant ..... *G. oculatus variegatus* (Guérin-Méneville) p. 311

Gelastocoris oculatus oculatus (Fabricius)

(Pl. I, figs. 1, 2; Pl. III, figs. 5, 8; Pl. IV, fig. 11; Pl. V, figs. 27, 28.)

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1926. *Gelastocoris subsimilis* Blatchley, Heteroptera of Eastern North America, p. 1025.
1929. *Gelastocoris californiensis* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 167, fig. 26.

Size. Male: Length, 6.1 to 8.0 mm.; width of pronotum, 4.0 to 5.3 mm.; width of abdomen, 3.9 to 5.2 mm. Female: Length, 6.7 to 9.3 mm.; width of pronotum, 4.3 to 5.9 mm.; width of abdomen, 4.4 to 6.0 mm.

Color. Extremely variable both as to color and pattern. Colors present are black, brown, red, orange, yellow, white and green. Legs are ringed with brown. It would be an endless and useless task to try to describe all of the combinations of colors and patterns. In general, the specimens from the southeastern United States are smaller and darker, while those from the rest of the United States tend to be larger and lighter, but both extremely dark and extremely light forms as well as all intermediates may be found in either area.

Structural characteristics. Apex of head rounded or weakly pointed; front moderately rough, provided with low, broad elevations which vary in size with the specimen; ocelli rather small, equal to or slightly larger than the blisterlike granules of the hemelytra. Pronotum with the disc moderately rough, though the degree of roughness varies with the specimen; lateral margin quite variable, usually with anterior portion subparallel for a distance equal to two-thirds the length of the ocellocular space, slightly divergent, then lateral margin extending diagonally posterolaterad to the lateral angle, in some specimens this portion of the lateral margin may be nearly transversal, usually this portion of the lateral margin is convex, more rounded toward the lateral angle, lateral margin weakly serrate; posterolateral margin extending diagonally posteromesad to base of embolium, serrate; lateral angle projecting laterad beyond the base of embolium; width of protonum subequal to width of abdomen; base of pronotum lacking short, longitudinal carinae. Hemelytra extending beyond the end of abdomen; membrane well-developed; basal half of lateral margin of embolium expanded, width of expansion about three times as wide as largest blisterlike granule, expansion forming an obtuse angle posteriorly. Connexivum prominent. The blisterlike granules few in number, slightly less in width than base of hind tarsus. Spatulate right side of seventh ventral abdominal segment of male about half covered by the preceding segment, not extending to the lateral margin of the abdomen; left side projecting posteriorly only slightly. Female ventral abdominal segments nearly symmetrical, the incision

may be symmetrical or bent to the left. Keel hood of male genitalia broadly triangular, apex blunt, an oval concavity near apex on the ventral surface, fringe nearly transversal, somewhat concave in center; keel hook present, rather stout, recurved and apex extending partially over pan; pan with apex thick, but narrow, about one-half width of base, with a slight depression on ventral surface, base more flattened, pan as whole in plane at right angle to the dorsoventral axis of the insect; right clasper hook quite variable, usually apical half digitiform, usually rather thin, transversal portion of base variable as to thickness, there may be a lateral projection present at the base of digitiform process, this also is variable in size; tumescence of right clasper not adnate to basal portion of clasper; anterolateral projection of keel absent.

Location of type. In the Kiel Museum, Kiel, Germany. This museum was destroyed during the recent war, but the Fabrician Collection was removed and saved. Doctor H. B. Hungerford visited the museum in 1928, and he reports that the type has been partially destroyed by dermestids and that only the hemelytra and scutellum remain. The type is labeled "Carolina".

Distributional data. This species has been reported from the United States to Brazil by various workers, but this worker has seen only three specimens from outside the limits of the United States: one from northern Mexico, the other two from Ontario. Since many of the species in this group are very similar in external appearance, it seems likely that reports of the typical subspecies from Central and South America are probably misidentifications. The writer has studied 1500 specimens or more from the following localities:

Alabama: Burnsville, July 20, 1930, R. H. Beamer, 1 female; Coatopa, July 18, 1930, P. W. Oman, 1 male; same place and date, R. H. Beamer, 2 females; Decatur, July 6, 1939, J. D. Beamer, 1 male and 1 female; Marion Jct., July 16, 1930, P. W. Oman, 2 males and 2 females; Mt. Meigs, July 21, 1930, R. H. Beamer, 1 female; same place and date, L. D. Tuthill, 1 male and 1 female; Tuskegee, July 22, 1930, P. W. Oman, 1 male and 1 female.

Arizona: Bill Williams Fork, Aug., F. H. Snow, 6 males and 8 females; Box Canyon, May 9, 1938, F. Parker, 1 male; Chiricahua Mts., Sept. 16, 1935, F. H. Parker, 1 female; Clifton, July 14, 1933, F. Parker, 2 males; Coconino Co., July 1, 1929, L. D. Anderson, 1 female; Congress Jct., July, F. H. Snow, 1 female; Doug-

las, Aug., F. H. Snow, 1 female; Fort Yuma, Aug. 4, Hubbard, 1 female; Grand Canyon, Aug. 11, 1927, L. A. Anderson, 2 males and 1 female; Humphrey's Peak, Aug., F. H. Snow, 1 female; Maricopa Co., July 1, 1929, L. A. Anderson, 1 female; same place and date, R. H. Beamer, 1 female; Oak Creek Canon, Aug., F. H. Snow, 1 female; same place, July 9, 1941, B. Hodgden, 5 males and 4 females; Prescott, 1 male and 4 females; Sabina Canyon, Sta. Catalina Mts., July 24, 1940, 2 males; same place, July 23, 1917, P. A. Munz, 1 male and 1 female; Sierra Ancha, July 19, 1927, 1 female; Tuscon, F. H. Snow, 28 males and 58 females; Southern Arizona, 2 females.

Arkansas: Fayetteville, Apr. 20, 1895, 1 male and 1 female; same place, Aug. 1923, 2 females; same place, Apr. 22, 1930, H. H. Schwardt, 1 male; same place, Apr. 23, H. H. Schwardt, 1 male and 1 female; Lawrence Co., nr. Imboden, June, 1925, B. C. Marshall, 1 male and 1 female (USNM); Ark., 1 male.

California: Alma, Santa Cruz Mts., Apr. 22, 1931, C. H. Martin, 1 female; Bakersfield, July 14, 1929, P. W. Oman, 2 females; same place, July 24, 1929, R. H. Beamer, 2 males and 1 female; Barrett, Cottonwood Creek, Apr. 13, 1930, C. H. Martin, 2 males and 2 females; Bautista Canyon, July 5, 1931, C. H. Martin, 1 female; Berkeley, April 26, 1933, Jean Linsdale, 1 male and 1 female; Cajon Pass, Aug. 6, 1936, R. H. Beamer, 1 female; Calexico, Aug. 1, 1931, H. W. Capps, 1 female; Claremont, 1916, M. H. Hatch, 2 males and 1 female; Cypress Rdg., Marion Co., March 29, 1921, C. T. Dodds, 1 female; Dulzura, Aug. 9, 1935, J. Beamer, 1 male and 2 females; Indio, July 24, 1929, P. W. Oman, 1 female; Lake Tahoe, Aug. 11, 1940, L. C. Kuitert, 2 males and 3 females; Los Angeles, W. T. Davis, 1 female; Los Angeles River, Oct. 24, 1915, 1 male; same place, Aug. 15, 1916, V. Duran, 1 female; Los Gatos Cr., Sept. 24, 1910, 1 female; Los Penasquitos Creek, Poway V., Apr. 10, 1930, C. H. Martin, 1 male and 4 females; same place, Apr. 11, 1930, C. H. Martin, 1 male; Lucerne, July 17, 1935, R. H. Beamer, 1 male; Marin Co., Aug. 3, 1929, L. D. Anderson, 2 males and 2 females; same place, no date or collector, 1 female; Mount Shasta, no date or collector, 1 male and 2 females; Palo Alto, Apr. 13, 1893, no collector, 1 female; same place, Apr. 24, 1893, no collector, 1 female; same place, Apr. 27, 1893, no collector, 2 males and 1 female; Pasadena, no date or collector, 1 male and 4 females; Pine Valley, July 27, 1938, R. I. Sailer, 1 male; Rio Hondo, Los Angeles Co.,

Mar. 21, 1930, C. H. Martin, 1 female; same place, Mar. 23, 1930, C. H. Martin, 1 male and 1 female; same place, Mar. 30, 1930, C. H. Martin, 1 male and 2 females; Rosamond, July 23, 1940, L. C. Kuitert, 1 male and 3 females; Salinas River, San Ardo, Apr. 25, 1930, C. H. Martin, 1 male and 1 female; San Diego, no date, Drake, 1 male; San Diego Co., Lake Hodges, Aug. 5, 1937, F. W. Furry, 1 female; San Gabriel River, March, 1930, C. H. Martin, 1 male and 1 female; San Jacinto Mts., July 21, 1929, R. H. Beamer, 1 female; same place and date, P. W. Oman, 1 male; San Luis Rey River, Apr. 15, 1930, C. H. Martin, 1 male and 2 females; San Mateo Creek, May 8, 1930, C. H. Martin, 1 male; San Mateo Co., no date, Heidemann, 1 female; San Pablo, Alameda Co., Apr. 30, 1921, C. T. Dodds, 2 males; S. Pablo Val., May 9, 1921, C. T. Dodds, 1 male and 1 female; Santa Ana Canyon, June 8, 1930, D. W. Martin, 2 males and 1 female; Santa Margarita Creek, May 8, 1930, C. H. Martin, 1 male and 1 female; Santa Margarita River, Apr. 8, 1930, C. H. Martin, 3 females; Santa Monica, Mar. 26, 1879, 1 male (Milw. Mus.); Sonoma Co., no date or collector, 1 male and 1 female; Stanford U., Sept. 12, 1909, no collector, 1 male; same place, Oct. 9, 1909, no collector, 1 male and 1 female; same place, Nov., 1910, no collector, 1 male; Sunol, May 8, 1921, C. T. Dodds, 1 male and 1 female; Sweetwater River, Descanso Jct., Apr. 13, 1930, C. H. Martin, 2 males and 1 female; Sweetwater River, San Diego Co., no date, W. J. Chamberlin, 2 males (Mich. Coll.); Warm Spring Creek, Temecula, April 18, 1930, C. H. Martin, 1 male and 1 female; Warner Sprgs., July 28, 1938, R. I. Sailer, 1 male and 1 female; Winters, Aug. 6, 1929, R. H. Beamer, 5 males and 7 females; same place and date, P. W. Oman, 2 males and 1 female; Vina, May 15, 1921, C. T. Dodds, 2 males; California, no date or collector, 1 female; Tehama Co., Redbluff, Aug. 28, 1926, C. L. Hubbs, 1 female.

Colorado: Colorado Springs, Aug., E. S. Tucker, 1 female; Fort Collins, Aug. 12, 1931, M. W. Sanderson, 1 male and 2 females; same place, July 16, 1900, no collector, 2 males.

District of Columbia: Brightwood, Apr. 30, 1901, Heidemann, 1 male; same place, May 20, Heidemann, 1 male; Rock Creek, June 17, 1893, Heidemann, 1 female; same place, July 8, 1893, Heidemann, 1 male; same place, June 19, 1902, Heidemann, 1 female; Washington, June, 1893, Heidemann, 1 female; same place, Mar. 2, 1894, Heidemann, 1 male; same place, June 8, 1894, Heidemann, 1 male; same

place, June 29, Heidemann, 1 male; same place, July 8, Heidemann, 2 females.

Florida: Biscayne, May 24, 1887, Heidemann, 1 male; Branford, July 31, 1930, R. H. Beamer, 1 male and 1 female; Chokolookee, no date or collector, 1 male; Crescent City, Apr. 1908, Van Duzee, 1 male and 1 female; Farmdale, June 27, 1948, E. L. Todd, 4 males and 4 females; Floral City, July 7, 1948, E. L. Todd, 8 males and 6 females; Ft. Pierce, Aug. 7, 1930, R. H. Beamer, 1 male and 1 female; Fort Walton, June 27, 1948, E. L. Todd, 1 female; Gulf Port, no date, A. G. Reynolds, 6 males and 2 females; Hilliard, Aug. 31, 1930, R. H. Beamer, 1 male and 1 female; Ind. River, no date or collector, 1 female (Milw. Mus.); Inglis, July 7, 1948, E. L. Todd, 6 males and 3 females; Labelle, Apr. 19, D. M. DeLong, 1 male; same place, July 16, 1939, R. H. Beamer, 2 females; same place, July 19, 1948, B. T. McDermott, 10 males and 8 females; same place and date, H. W. Crowder, 1 male and 1 female; same place and date, E. L. Todd, 54 males and 43 females; same place, Apr. 19, J. N. Knull, 5 females; same place and date, D. M. DeLong, 2 males and 2 females; Lacoochee, Aug. 18, 1930, P. W. Oman, 2 males and 1 female; same place, July 7, 1948, E. L. Todd, 16 males and 14 females; Lake Placid, Feb. 13, 1943, M. Cazier, 1 female; same place, July 13, 1948, B. T. McDermott, 3 males and 4 females; same place and date, H. W. Crowder, 7 males and 3 females; same place and date, E. L. Todd, 24 males and 16 females; Leon Co., Lake Jackson, June 22, 1922, J. S. Alexander, 1 male and 1 female; Liberty Co., Apr. 16, 1938, F. E. Lutz, 1 female; Lake Worth, Feb. 6, 1924, C. S. Bromley, 1 female; Liberty Co., Rock Bluff, July 19, 1930, H. Spieth, 1 female; M'Glamery Co., Apr. 2, 1927, C. O. Bare, 18 males and 13 females; Moore Haven, Apr. 17, D. M. DeLong, 2 males; same place and date, J. N. Knull, 1 male and 3 females; Otter Creek, July 6, 1948, B. T. McDermott, 7 males and 6 females; same place and date, R. H. Beamer, 2 females; same place and date, H. W. Crowder, 6 males and 2 females; same place and date, E. L. Todd, 26 males and 23 females; Paradise, Ky., Apr. 10, J. N. Knull, 4 males and 2 females; Pensacola, June 26, 1948, R. H. Beamer, 1 male and 2 females; Perrine, no date or collector, 22 males and 15 females; Royal Palm Pk., Sept. 18, 1930, no collector, 1 male and 2 females; same place, Oct. 18, 1930, no collector, 1 male and 1 female; Suwannee Sprgs., July 3, 1948, B. T. McDermott, 1 female; Tavures, July 18, 1894, Heidemann, 2 females; Torreya Ravine, Liberty Co., Apr. 15, 1938, F. E. Lutz, 1 male and 1 female;

Wakulla Sprgs., July 14, 1934, R. H. Beamer, 1 male; Wakulla, June 29, 1948, R. H. Beamer, 3 males and 4 females; same place and date, B. T. McDermott, 7 males and 13 females; same place and date, H. W. Crowder, 6 males and 5 females; same place, June 30, 1948, E. L. Todd, 12 males and 8 females; Winter Park, Mar. 21, 1938, F. E. Lutz, 1 female; Fla., no date or collector, 1 male and 1 female.

Georgia: Atlanta, May 14, 1911, J. C. Bradley, 1 male; Clayton, May 18-26, 1911, J. C. Bradley, 1 male and 1 female; Floyd Co., Rome, July 13, 1930, C. F. Byers, 1 female; Okefenokee Swamp, Aug. 3, 1934, R. H. Beamer, 1 female; same place, July 25, 1939, D. E. Hardy, 1 female; same place and date, J. D. Beamer, 5 males and 5 females; same place, Aug. 1, 1939, R. H. Beamer, 2 males; Spring Creek, Decatur Co., June 7-23, 1911, J. C. Bradley, 2 males and 4 females; Thomasville, July 31, 1927, C. H. Martin, 1 female; same place, Aug. 21, 1927, C. H. Martin, 1 male and 1 female; same place, Aug. 28, 1927, C. H. Martin, 1 female; same place, June 30, 1948, B. T. McDermott, 1 female; same place and date, E. L. Todd, 3 females; same place, Mar. 26, 1903, no collector, 1 male.

Idaho: Parma, Sept. 4, 1934, C. H. Martin, 1 male; Juliaetta, no date or collector, 1 male and 1 female; Id., no date or collector, 1 male.

Illinois: Villa Ridge, June 7, 1892, no collector, 1 male.

Indiana: Jefferson Co., Hanover, Aug. 28, 1922, T. H. Hubbell, 1 female (Mich. Coll.); Kosciusko Co., May 13, 1932, G. E. Gould, 1 male and 1 female; Lake Co., Gary, no date, H. Ramstadt, 1 female (Mich. Coll.); Warsaw, Apr. 19, 1932, G. E. Gould, 1 male and 1 female.

Kansas: Bourbon Co., 1915, R. H. Beamer, 1 male; Chanute, no date, G. Wiley, 3 males; same place, Dec. 20, 1919, H. B. Hungerford, 1 male and 1 female; Cherokee Co., Aug. 1920, H. B. Hungerford and R. H. Beamer, 7 males and 10 females; same place, Aug. 29, 1926, R. H. Beamer, 3 males and 3 females; Coldwater, Sept. 7, 1923, C. O. Bare, 3 males and 1 female; same place, Apr. 1925, R. H. Beamer and C. O. Bare, 5 males and 4 females; same place, June 19, 1927, R. H. Beamer, 1 male and 1 female; Comanche Co., Aug. 1922, C. O. Bare, 2 males and 2 females; same place, Aug. 23, 1924, C. O. Bare, 5 males and 5 females; Douglas Co., Oct. 23, 1926, H. B. Hungerford, 1 male and 1 female; same place, Oct. 8, 1946, B. Hodgden, 2 males; same place, Apr. 4, 1948, G. T. Brooks, 1 male and 3 females; same place, Apr. 8, 1950, W. Smith,

3 males and 1 female; Ellsworth Co., July 3, 1923, C. H. Martin, 1 male; Graham Co., Aug. 16, 1912, F. X. Williams, 5 males and 2 females; Great Bend, Oct., 1920, Cavanaugh, 5 females; Lake View, Oct., 1925, H. B. Hungerford, 1 male and 1 female; Logan Co., no date, F. X. Williams, 3 males and 4 females; Meade Co., 13 mi. SW Meade, Aug., 1939, C. W. Hubbard, 1 female (Mich. Coll.); same place, no date or collector, 1 male; Montgomery Co., Elk City, 1927, H. B. Hungerford, 2 males and 1 female; Morton Co., July 20, 1924, C. O. Bare, 21 males and 15 females; Neosho Co., 1919, G. Wiley, 5 males and 5 females; Norton Co., Aug. 24, 1912, F. X. Williams, 1 male; Onaga, July 13, 1925, R. H. Beamer, 1 female; Pawnee Co., July 26-Aug. 2, 1917, no collector, 7 males and 3 females; same place, no date, H. B. Hungerford, 7 males and 10 females; Reno Co., Oct. 4, Lantz, 1 male; Rice Co., July 3, 1923, R. H. Beamer, 6 males; same place, July, 1923, C. H. Martin, 1 female; same place and date, L. C. Woodruff, 1 female; Riley Co., Apr. 22, 1924, R. H. Beamer, 1 female; same place, Sept. 20, J. B. Norton, 17 males and 3 females; Saline Co., July 14, 1923, W. B. Whitlow, 1 male and 3 females; Shawnee Co., Apr. 1, 1945, A. M. Egbert, 1 female; Wallace Co., no date, F. X. Williams, 1 male and 3 females; same place, no date or collector, 1 female; Yates Center, July 30, 1923, R. H. Beamer and P. B. Lawson, 1 male and 1 female.

Kentucky: Pineville, July 20, 1924, G. P. Engelhardt, 2 males and 2 females.

Louisiana: Aloha, Dec. 23, 1931, R. H. Beamer, 1 female; Covington, June 23, 1948, R. H. Beamer, 3 males and 2 females; same place and date, E. L. Todd, 14 males and 15 females; Creole, June 17, 1948, R. H. Beamer, 2 males; same place, June 18, 1948, L. D. Beamer, 1 male; same place and date, E. L. Todd, 7 males and 9 females; Denham Sprgs., June 20, 1948, E. L. Todd, 1 female; Madison Parish, Allig. bayou, July 4, 1930, R. Bunn, 2 males and 1 female; Mandeville, June 24, 1948, R. H. Beamer, 1 male; same place and date, B. T. McDermott, 1 female; same place, June 25, 1948, E. L. Todd, 2 males and 3 females; Mound (No. 276), May 25, 1918, no collector, 2 males and 4 females; same place (No. 301), June 11, 1918, no collector, 2 males; Natchitoches Parish, Apr. 30, 1915, K. P. Schmidt, 1 male and 2 females.

Maryland: Glen Echo, June 9, O. Heidemann, 1 female; Grt. Falls, May 13, 1890, Heidemann, 1 male; Plum Island, July 18, 1909, G. P. Engelhardt, 1 female; Md., July 4, 1886, Heidemann, 1 female.

Michigan: Ann Arbor, May 20, 1932, no collector, 1 male (Mich.

Coll.); same place, May 30, 1929, W. Clanton, 1 male and 1 female (Mich. Coll.); Berrien Co., New Buffalo, Sept. 2, 1919, R. F. Hussey, 10 males and 7 females (Mich. Coll.); Berrien Co., E. K. Warren Preserv., Sand Dunes, Aug. 31, 1919, R. F. Hussey, 25 males and 18 females (Mich. Coll.); Berrien Co., E. K. Warren Preserv., Warren Woods, Sept. 1, 1919, R. F. Hussey, 3 males and 2 females (Mich. Coll.); Huron Co., Port Austin, Aug. 28, 1924, F. M. Gaige, 21 males and 13 females (Mich. Coll.); Huron Co., Sand Point, July 30, 1934, I. J. Cantrall, 1 female (Mich. Coll.); same place, Sept. 13, 1927, F. M. Gaige, 1 male (Mich. Coll.); Midland Co., Apr. 4, 1932, R. R. Dreisbach, 1 male (Mich. Coll.); Midland Co., Chippewa R., 8 mi. W Midland, July 15, 1935, A. Olson-L. K. Gloyd, 1 female (Mich. Coll.); Monroe Co., 3 mi. W Temperance, Aug. 12, 1941, I. J. Cantrall, 5 females (Mich. Coll.); Montcalm Co., no date or collector, 2 females (Mich. Coll.); Ottawa Co., Sept. 5, 1940, G. Orton, 1 male and 1 female (Mich. Coll.); Sanilac Co., 36 mi. S Port Sanilac, June 29, 1941, A. Watson, 1 male and 1 female (Mich. Coll.); Walnut Lake, June 26, 1906, no collector, 3 females; Washtenaw Co., Apr. 28, 1932, no collector, 1 male (Mich. Coll.); same place, May 18, 1933, no collector, 1 male (Mich. Coll.); same place, May 23, 1933, no collector, 2 males (Mich. Coll.); same place, Apr. 23, 1935, no collector, 1 female (Mich. Coll.); Washtenaw Co., Ann Arbor, May 18, 1933, R. M. Bailey, 1 male (Mich. Coll.); same place, May 24, 1932, R. M. Bailey, 1 female (Mich. Coll.); same place, May 8, 1937, J. J. Friauf, 3 males and 3 females (Mich. Coll.); Washtenaw Co., Irish Hills, May 15, 1932, R. M. Bailey, 1 female (Mich. Coll.); Washtenaw Co., North Lake, Sept. 22, 1935, L. J. Cantrall, 1 female (Mich. Coll.); Washtenaw Co., Sylvan Twp., Crooked Lake, May 8, 1937, D. L. and I. J. Cantrall, 6 males and 2 females (Mich. Coll.); Washtenaw Co., Third Sister Lake, Sept. 1, 1935, L. K. Gloyd, 3 males (Mich. Coll.); Washtenaw Co., Whitmore Lake, May 22, 1932, R. M. Bailey, 1 female (Mich. Coll.); Cheboygan Co., Maple River, Douglas L. and Black Lake, H. B. Hungerford, not common.

Mississippi: Hamilton, July 15, 1930, R. H. Beamer, 1 male and 2 females; Iuka, July 14, 1930, R. H. Beamer, 1 male and 1 female; Pass Christian, June 25, 1948, R. H. Beamer, 2 males and 3 females; same place and date, E. L. Todd, 6 males and 10 females; Smithville, July 15, 1930, R. H. Beamer, 1 female; Tuskegee, July 22, 1930, R. H. Beamer, 3 females.

Missouri: Black R., Clark Nat. Forest, July 22, 1937, C. P. Brown, 1 female (Mich. Coll.); Blackwell, May, 1910, J. F. Abbot, 1 female; Hollister, July 28, 1929, no collector, 1 male and 1 female; Postosi, June 28, 1923, W. J. Clench, 1 female; St. Louis, Creul-Coenir Lake, May, 1910, J. F. Abbot, 1 male; Van Buren, Ozark Mts., June 7, 1930, E. A. Pence, 2 females (Mich. Coll.); same place, June 16, 1930, E. A. Pence, 3 males and 1 female (Mich. Coll.); same place, June 12, 1930, E. A. Pence, 2 males (Mich. Coll.); same place, June 20, 1930, E. A. Pence, 1 male (Mich. Coll.); same place, July 9, 1930, E. A. Pence, 1 female (Mich. Coll.).

Nebraska: Jefferson Co., Apr. 20, 1924, H. B. Hungerford and R. H. Beamer, 2 females.

Nevada: Carson City, Aug. 9, 1929, R. H. Beamer, 1 female; same place, July, 1930, Wickham, 1 female; Reno, Sept. 14, 1940, LaR., 1 female; same place, Apr. 19, 1941, LaR., 1 female.

New Jersey: Anglesea, May 30, no collector, 1 male; Lakehurst, Sept. 4, 1911, F. M. Schott, 2 females; Rancoca, Aug. 29, 1927, E. M. Becton, 4 males and 4 females; Trenton, Aug. 8, no collector, 1 male.

New Mexico: Catron Co., Aug. 15, 1938, J. Hildalgo Jr., 5 males and 4 females; Monzano, June 26, 1941, B. Hodgden, 1 male; State College, Dona Ana Co., Oct. 5, 1936, no collector, 1 female; Valencia Co., McCartys, Sept. 19, 1926, C. L. Hubbs, 2 females (Mich. Coll.)

North Carolina: Charlotte, July 20, 1936, C. D. Lyman, 1 male (Mich. Coll.); Haywood Co., Crestmont, July 27, 1922, T. H. Hubbell, 3 females (Mich. Coll.); Hertford, no date, W. R. Walton, 1 male (USNM); Lake Ellis, May 8, 1906, no collector, 1 male; Roanoke Is., July 25, no collector, 2 females; Raleigh, Mar. 21, 1905, no collector, 3 males; same place, Mar. 24, 1905, no collector, 2 males and 3 females; same place, Mar. 25, 1905, no collector, 1 male; same place, Mar. 31, 1906, C. S. Brimley, 1 male and 2 females; same place, Apr. 7, 1906, C. S. Brimley, 1 male and 1 female; same place, Apr. 13, 1906, C. S. Brimley, 3 males and 3 females; same place, May 25, no collector, 1 male and 1 female; Southern Pines, May 15, 1919, A. H. Manee, 3 males; Whitney, Apr. 22, 1907, no collector, 1 female; North Carolina, no date or collector, 1 female.

Ohio: Columbus, no date or collector, 1 female; Hooking Co., Good Hope Twp., Sept. 17, 1931, R. M. Bailey, 1 female (Mich.

Coll.); Lucas Co., Spencer Twp., Sept. 24, 1938, I. J. Cantrall, 12 males and 13 females (Mich. Coll.); Lucas Co., 6 mi. W Toledo, Sept. 24, 1938, I. J. Cantrall, 2 males and 2 females (Mich. Coll.).

Oklahoma: Comanche Co., Wichita Natl. Forest, June 11, 1926, T. H. Hubbell, 1 male (Mich. Coll.); McCurtain Co., Glover, June 16, 1938, W. F. Blair, 1 male.

Oregon: Boardman, July 15, 1931, L. D. Anderson, 1 male; Corvallis, Sept. 16, 1897, no collector, 1 male; same place, Sept. 28, 1899, no collector, 1 female; same place, 1906, Woods, 1 female; same place, Aug. 1907, no collector, 1 female; same place, Sept. 21, 1907, no collector, 1 female; Dilley, Aug. 20, 1902, no collector, 8 males and 9 females; Dixie, July 9, 1931, L. D. Anderson, 1 male; Eugene, July 15, 1941, Malkin, 1 female; Freewater, Sept. 8, 1914, G. F. Moznette, 1 male; same place Sept. 9, 1914, G. F. Moznette, 1 male; same place, Sept. 21, 1914, G. F. Moznette, 1 female; Grant's Pass, Rogue R., Sept. 14, 1930, F. H. C., 1 male and 1 female; same place, Sept. 24, F. R. C., 1 female; Hood R., July 17, 1931, L. D. Anderson, 1 female; Monroe, June 18, 1930, M. H. Hatch, 1 female; Philomath, 1905, no collector, 1 female; St. Angel, no date, Heidemann, 1 male.

South Carolina: Cheraw, Apr. 24, 1938, F. E. Lutz, 1 male (AMNH); same place, Apr. 14, 1938, F. E. Lutz, 2 females (AMNH); same place, Apr. 7, 1938, F. E. Lutz, 1 female (AMNH).

Tennessee: Clarksville, July 3, 1939, E. G. Wegenek, 1 female; Coal Creek, June 28, 1916, W. S. Adkins, 2 males; Cumberland Co., Grassy Cove, July 14, 1922, T. H. Hubbell, 1 male (Mich. Coll.); same place, July 7, 1922, T. H. Hubbell, 1 female (Mich. Coll.); Elkmont, May 4, 1913, no collector, 1 female; Kenton, Aug. 4, 1948, B. T. McDermott, 3 males; Knoxville, June 6, 1890, no collector, 2 males and 2 females; same place, Apr. 25, 1911, no collector, 3 males and 2 females; same place, Apr. 11, 1914, no collector, 1 female; same place, May, 1914, no collector, 1 male and 1 female; same place, July 15, 1919, no collector, 1 male; same place, June, 190?, no collector, 1 male; Obion Co., Reelfoot Lake, Sept. 8, 1919, F. M. Gaige, 6 males and 5 females (Mich. Coll.); same place, Sept. 6, 1919, F. M. Gaige, 3 males and 5 females (Mich. Coll.); Perryville, July 20, 1926, T. E. White, 1 female; Scott Co., Big South Fork of Cumberland River, July 24, 1924, T. H. Hubbell, 1 female (Mich. Coll.); Thunderhead Mt., Blount Co., July 19, 1927, G. Steyskal, 2 males (Mich. Coll.).

Texas: Austin, Oct. 12, 1923, R. K. Nabors, 6 males; same place, Oct. 1899, no collector, 1 female; same place, Oct. 1900, A. L. Melander, 3 males and 1 female; same place, Nov. 18, 1899, no collector, 1 male; Burton, June 24, 1938, L. W. Hepner, 2 females; Cisco, June 19, 1947, R. Olmsted, 1 male; same place and date, L. D. Beamer, 1 female; Colorado Co., Apr. 3, 1922, G. Wiley, 17 males and 11 females; same place, Apr. 7, 1922, G. Wiley, 2 males; same place, Apr. 11, 1922, G. Wiley, 13 males and 11 females; same place, Apr. 14, 1922, G. Wiley, 1 female; same place, Apr. 24, 1922, G. Wiley, 3 males; same place, May 6, 1922, G. Wiley, 1 male; same place, May 11, 1922, G. Wiley, 1 male and 1 female; same place, May 15, 1922, G. Wiley, 2 males; same place, May 16, 1922, G. Wiley, 9 males and 3 females; Comal Co., no date or collector, 1 male and 3 females; Concan, July 6, 1936, R. H. Beamer, 1 female; Dallas Co., Apr. 14, 1938, Cole, 1 female; same place, Mar. 9, 1939, D. D. Millspaugh, 3 males and 1 female; same place, summer, 1931, J. K. G. Silvey, 3 females (Mich. Coll.); Eastland Co., May 6, 1921, G. Wiley, 1 female; same place, May 12, 1921, G. Wiley, 1 male; same place, May 17, 1922, G. Wiley, 1 male and 1 female; Guadalupe Co., 6 mi. N New Braunfels, Feb. 22, 1946, I. J. Cantrall, 3 males and 1 female (Mich. Coll.); Peeler, June 22, 1938, D. W. Craik, 1 male and 1 female; Sequin, June 26, 1938, R. I. Sailer, 1 female; Tarrant Co., summer 1931, J. K. G. Silvey, 1 female (Mich. Coll.); Webb Co., summer 1931, J. K. G. Silvey, 1 male (Mich. Coll.); Willis, May, 1903, Bridwell, 1 female; Texas, no date or collector, 3 males and 2 females; Texas, summer 1931, J. K. G. Silvey, 2 males and 1 female.

Utah: Beav. Cany., no date or collector, 1 male and 1 female.

Washington: Dayton, Apr. 17, 1934, C. H. Martin, 1 male and 1 female; Kalama R., July 21, 1931, L. D. Anderson, 3 males; same place and date, J. Nottingham, 1 female; Mason Co., Lake Cushman, June 24, 1919, F. M. Gaige, 1 female (Mich. Coll.); Pasco, Apr. 17, 1934, C. H. Martin, 2 males and 1 female; Pullman, no date, C. V. Piper, 2 females.

Wisconsin: Milw. Co., Sept. 1, 1900, C. E. Brown, 1 female (Milw. Mus.).

Ontario: Lambton Co., Stag Isl., Sept. 26, 1927, S. Moore, 1 male and 1 female (Mich. Coll.).

Mexico: Río Corona, 18 mi. NE Victoria, Tamaulipas, Dec. 17, 1941, Cantrall-Friauf, 1 female (Mich. Coll.).

Africa: Cape of Good Hope, no date or collector, 2 females.

These specimens quite obviously have been mislabeled, they may have come from Good Hope Twp., Ohio, a locality from which the writer has seen other specimens.

Comparative notes. With the exception of *G. rotundatus* Champion, this is the only species the writer has seen from within the limits of the United States. It may be separated from the closely related species by the shape of the lateral margin of the pronotum and/or male genitalia. *G. californiensis* Melin is in the opinion of the writer a synonym of *G. oculatus oculatus* (Fabr.) and is so treated. The characters utilized in the separation of this species fall within the range of variation of *G. oculatus oculatus* (Fabr.) and are therefore not valid.

Gelastocoris oculatus variegatus (Guérin-Méneville)

(Pl. IV, fig. 16; Pl. VI, fig. 31)

1844. *Galgulus variegatus* Guérin-Méneville, Iconographie du Règne Animal de B. Cuvier., part 7, p. 352.
1859. *G. variegatus* Dohrn, Catalogue Hemipterorum, p. 53.
1873. *G. variegatus* Uhler, Bull. U. S. Geol. Survey, vol. I, no. 5, pp. 336-337.
1876. *G. variegatus* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, no. 4, p. 137.
1878. *G. variegatus* Uhler, Wheeler's Rept. to Chief of Engineers for 1877, p. 1331.
1886. *G. variegatus* Uhler, Bull. Brooklyn Ent. Soc., p. 27.
1894. *G. variegatus* Uhler, Proc. California Acad. Sci., ser. 2, vol. IV., p. 290.
1901. *Gelastocoris variegatus* (Guérin-Méneville); Champion, Biologia Centrali-Americana, Rhynchota Heteroptera, vol. II, pp. 349-350, pl. XX, figs. 19, 20.
1906. *G. variegatus* Baker, Brooklyn Inst., Sci. Bull., vol. I, p. 288.
1909. *G. variegatus* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 181.
1910. *G. variegatus* Montandon, Annuario del Museo Zoologico della R. Università di Napoli (nuova serie), vol. 3, no. 10, p. 2.
1910. *G. variegatus* Banks, Cat. Nearctic Hemip-Heteroptera, p. 11.
1914. *G. variegatus* Van Duzee, Trans. San Diego Soc. Nat. Hist., II, p. 33.
1917. *G. variegatus* Van Duzee, Catalogue of Hemiptera, Univ. California Publ., p. 473.
1929. *G. variegatus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 162-163, figs. 7, 21.
1929. *G. variegatus* Martin, Univ. Kans. Sci. Bull., vol. XVIII, no. 4, p. 362, pl. 58, fig. 8; pl. 59, fig. 10.
1939. *G. variegatus* Millspaugh, Field and Laboratory, vol. VII, no. 2, p. 82.
1952. *G. variegatus* Ellis, Am. Midland Nat., vol. 48, no. 2, p. 310.

Also referring to this subspecies:

1854. *Galgulus pulcher* Stål, Ofversigt af Kongl. Vetenskaps-Akademiens Forhandlingar, Band XI, no. 3, p. 239.
1859. *G. pulcher* Dohrn, Catalogus Hemipterorum, p. 53.
1873. *G. pulcher* Walker, Catalogue of Hemiptera in British Museum, part VIII, p. 171.
1876. *G. pulcher* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, no. 4, p. 137.
1909. *Gelastocoris pulcher* (Stål); Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 180.
1929. *G. pulcher* Martin, Univ. Kansas Sci. Bull., vol. XVIII, no. 4, p. 362.

Size. Male: Length, 5.7 to 6.5 mm.; width of pronotum, 3.4 to 4.2 mm.; width of abdomen, 3.5 to 4.2 mm. Female: Length, 6.6 to 7.5 mm.; width of pronotum, 4.3 to 4.7 mm.; width of abdomen, 4.3 to 4.8 mm.

Color. Variegated, in general appearance usually light brown with patches of white and brown or black. Some specimens with areas of red, the amount varying with the individual specimen. Below, with the abdominal segments lighter laterally; legs ringed with light brown.

Structural characteristics. Apex of head rounded or slightly pointed; front of head with moderate, broad, elevations; ocelli rather small, slightly smaller than the largest blisterlike granules. Disc of pronotum not very rough; lateral margin with anterior portion subparallel to longitudinal axis of body, for a distance equal to two thirds the length of the ocellocular space, then lateral margin extending almost directly laterad to the lateral angle, posterolateral margin strongly projecting for anterior two thirds, posterior third converging from the projection to the posterior angle of pronotum, anterior two thirds of posterolateral margin very strongly serrate; lateral angle projecting beyond base of embolium; width of pronotum subequal to width of abdomen; base of pronotum lacking short, longitudinal carinae. Hemelytra extending to or beyond end of abdomen; membrane well developed; basal half of lateral margin of embolium expanded, about two times as wide as largest blisterlike granules, lateral margin serrate, expansion angulate posteriorly. Connexivum visible in both sexes, but a little more evident in the females than in the males. The blisterlike granules not very numerous, usually five or six in number on each hemelytron, largest granule about as wide as base of hind tarsus. Seventh ventral abdominal segment of male with the spatulate right side partially covered by preceding segment, spatulate right side short not reaching lateral margin, broad, quite rounded and constricted at base of spatula; left side projecting posteriorly only slightly. Female ventral abdominal segments nearly symmetrical, incision bent to the left. Male genitalia practically identical to those of *G. oculatus oculatus* (Fabricius).

Location of type. Unknown. Guérin-Méneville's types were in the Museo Zoologico della R. Università di Napoli, Italy. This museum building was destroyed during World War II and I have not been able to determine whether the collections had been removed or whether they were lost.

Distributional data. Described from the Bay of Campeche, Mexico, this subspecies seems to be restricted to Central America and Mexico. The writer has seen authenic *G. o. variegatus* (Guérin-Méneville) from Brownsville, Texas, and it is possible that this species might be found in other semitropical areas of the southwestern United States but the writer has yet to see such specimens. Champion gives the distribution of this species to be southern and southwestern United States to Argentina. The writer has not seen this species from any of the South American countries and it seems quite unlikely that the species occurs in any of the southern states of the United States. Specimens from the following localities have been examined:

Texas: Brownsville, Oct. 13, 1944, R. L. Usinger, 1 male (Usinger Coll.). Other specimens from Brownsville are in the collections of the U. S. National Museum.

Mexico: San Bernardo, Río Mayo, Sonora, Oct. 14, 1934, H. S. Gentry, 2 females; Oaxaca, Oax., Sept. 19, 1923, E. G. Smyth, 1 female (USNM); same place, Aug. 20, 1937, M. Embury, 3 males; Vera Cruz, V. C., no date, Wickham, 2 males and 1 female.

Guatemala: Gualán, Jan. 14, 1905, no collector, 6 males and 2 females; same place and date, Drake, 1 male; Los Amates, Jan. 16, 1905, no collector, 4 males and 2 females; same place, no date or collector, 1 male and 2 females (MCZH).

Honduras: Progreso, Nov. 29, 1923, T. H. Hubbell, 1 male and 1 female.

British Honduras: Río Grande, Jan. 1932, J. J. White, 17 males and 11 females.

Panamá: Progreso, Chiriquí Prov., Apr. 18, 1923, F. M. Gaige, 4 males and 1 female.

Comparative notes. The original description was based entirely upon color. Because of this numerous specimens of *G. oculatus oculatus* (Fabr.) and other species have been identified as *G. variegatus* (Guérin-Méneville). Champion pointed out that the middle portion of the lateral margin extends transversely at nearly right angles to the longitudinal axis of the body. Champion speaks as if this were well known, so he may have received this information from Montandon and assuming that it had previously been published. On this character alone, it is possible to recognize the subspecies, though some specimens of *G. oculatus oculatus* (Fabr.) approach this subspecies in the shape of the lateral margin of the pronotum, but to my knowledge there is no cline for this character.

The genitalia, as mentioned above, are practically identical to those of the typical subspecies, differing no more from this subspecies than the individual variation within that subspecies. In consideration of the similarity of the male genitalia, it seems best for the present to place *G. variegatus* (Guérin-Méneville) as a subspecies of *G. oculatus* (Fabricius).

Gelastocoris rotundatus Champion

(Pl. IV, fig. 18; Pl. VI, fig. 30)

1901. *Gelastocoris rotundatus* Champion, Biologia Centrali-Americana, Rhynchota Heteroptera, vol. II, pp. 347-348, pl. 20, fig. 18.
1909. *G. rotundatus* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 180.
1929. *G. rotundatus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 155-156, fig. 10.
1929. *G. rotundatus* Martin, Univ. Kansas Sci. Bull., vol. XVIII, no. 4, p. 363, Pl. 58, fig. 16, Pl. 59, figs. 8, 19e and 19f.
1939. *G. rotundatus* Millspaugh, Field and Laboratory, vol. VII, no. 2, p. 83.
1951. *G. rotundatus* Adams and McNeill, Pan-Pacific Entomologist, vol. XXVII, no. 2, p. 71.

Size. Male: Length, 6.4 to 7.8 mm.; width of pronotum, 4.1 to 5.0 mm.; width of abdomen, 4.5 to 5.5 mm. Female: Length, 7.1 to 8.7 mm.; width of pronotum, 4.5 to 5.3 mm.; width of abdomen, 5.0 to 5.8 mm.

Color: Quite variable as in other species, mostly light yellowish-brown, others decidedly reddish, grey or black. Specimens may be nearly concolorous or with distinct patterns, *i. e.*, scutellum and disc of pronotum black, rest light yellow or yellowish brown.

Structural characteristics. Body almost oval due to peculiar form of pronotum. Apex of head rounded; front not especially rough; ocelli moderate in size, slightly larger than largest blisterlike granules. Pronotum with disc rather smooth; lateral margin of pronotum very slightly concave anteriorly then extending posterolaterad to lateral angle, usually slightly convex; lateral angle bent ventrad, not at all visible from above, only very slightly projecting laterad beyond base of embolium; abdomen wider than pronotum; base of pronotum lacking short, longitudinal carinae. Hemelytra extending to or beyond the end of the abdomen; membrane well developed; basal half of lateral margin of embolium scarcely expanded laterally, entire lateral margin of embolium nearly smooth and rounded. Connexivum completely or nearly completely covered by the hemelytra. Blisterlike granules few, small, the largest less than width of hind tarsus in size, all granules are small and rather uniform. Spatulate right side of seventh ventral abdominal

segment of male short, rounded, not extending to the lateral margin of the abdomen; left side not or only slightly projecting posteriorly. Female ventral abdominal segments nearly symmetrical, incision of the posterior margin of last segment slightly bent to the left. Keel hood of male genitalia covering apex of keel, fringe more or less concave in middle and bent rather abruptly anterolaterad on left side; keel hook present, recurved back toward base of pan; pan not very large, apex flattened at right angles to the base, round and with a slight crescent-shaped depression on ventral half; right clasper hook reduced, apical portion digitiform, short, basal transverse portion widest at base, slight lateral projection present at base of digitiform apex; tumescence of right clasper not adnate to base of clasper; anterolateral projection of keel absent.

Location of type. In the British Museum at London, England.

Distributional data. Champion gives the distribution of this species as Mexico and Guatemala. Martin reported it from Arizona and Millspaugh has reported it from Texas. Adams and MacNeill have recently reported this species from San Bernardino Co., California. The writer has examined specimens from the following localities:

Texas: Glenn Spring, Brewster Co., June 21, 1928, F. M. Gaige, 3 males and 8 females, (Mich. Coll.); Kerr Co., Apr. 9, 1939, D. Millspaugh, 2 females.

Arizona: Castle Hot Springs, Aug. 5, 1941, R. H. Beamer, 7 males and 13 females; same place and date B. Hodgden, 25 males and 29 females; same place and date, L. H. Banker, 4 males and 3 females; same place and date, E. L. Todd, 1 male; Douglas, Aug., F. H. Snow, 2 females.

Mexico: Corriente, Aug. 24, 1927, H. D. Thomas, 1 male and 3 females; Colima Vulcano, no date, L. Conrad, 1 male; San Luis de Barbarocos, Chihuahua, Dec. 30, 1934, H. S. Gentry, 1 female; Garrapatas, Gro., kil. 369 S Mex. City, Oct. 31, 1936, H. D. Thomas, 1 female; La Sabana, Guerrero, kil. 226 S Mex. City, Oct. 10, 1936, H. D. Thomas, 9 males and 9 females; Río Balsas, jct. Acapulco Hwy., Guerrero, June 24, 1932, H. Smith, 1 female; Tecolotlán, Jalisco, July 16, 1938, H. D. Thomas, 2 females; same place, Sept. 14, 1938, L. J. Lipovsky, 2 males and 1 female; Union de Tula, Jalisco, Sept. 16, 1938, H. D. Thomas, 13 males and 7 females; El Sabino, Uruapán, July 20, 1936, H. D. Thomas, 5 males and 1 female; Near Chinapa, Michoacán, Sept. 5, 1938, H. D. Thomas, 1 male and 2 females; Tancítaro,

Michoacán, July 29, 1940, H. Hoogstraal, 4 males and 3 females; Alpuyeca, Morelos, 102 km. S Mexico (city), Oct. 15, 1936, H. D. Thomas, 1 male; Cuernavaca, Morelos, Aug. 3, 1938, L. J. Lipovsky, 1 female; Rio Amacuza, Morelos, 133 km. S Mexico (city), Oct. 14, 1936, H. D. Thomas, 1 male and 1 female; Palmar Dist., Álamos, Sonora, Oct. 27, 1934, H. S. Gentry, 4 males and 6 females; Arroyo de los Mascales, Río Mayo, Sonora, Feb. 16, 1935, H. S. Gentry, 2 females; San Bernardo, Río Mayo, Sonora, October 14, 1934, H. S. Gentry, 8 males and 6 females; Tejupilco, Dist. of Temascaltepec, June-July, 1933, H. E. Hinton, 8 males and 9 females; near Tarandacuao, Aug. 6, 1932, H. Smith, 2 males and 1 female; "Mex.", no date and no collector, 1 female (MCZH).

Guatemala: Gualán, July 14, 1905, no collector, 1 male; Sonarate, no date, Kellerman, 1 female (MCZH); "Guatemala", no date or collector, 5 males and 3 females (MCZH), 1 female compared with type by Doctor H. B. Hungerford.

Honduras: Copán, Feb. 16, 1937, C. Roys, 1 male.

Comparative notes. The oval shape of the body and the shape of the pan of the male genitalia will separate this species from *G. oculatus* (Fabricius) to which it is apparently closely related.

Gelastocoris hungerfordi Melin

(Pl. V, fig. 19; Pl. VI, fig. 33)

1929. *Gelastocoris hungerfordi* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 168, figs. 5, 27-31.

Also referring to this species:

1929. *Gelastocoris cucullatus* Martin, Univ. Kans. Sci. Bull., vol. XVIII, no. 4, pp. 363-364, pl. 58, fig. 6, pl. 59, figs. 11, 12, 13.
1939. *G. cucullatus* Millspaugh, Field and Laboratory, vol. VII, no. 2, pp. 82-83.

Size. Male: Length, 5.9 to 6.5 mm.; width of pronotum, 3.5 to 4.1 mm.; width of abdomen, 3.6 to 4.2 mm. Female: Length, 6.2 to 7.4 mm.; width of pronotum 3.9 to 4.5 mm.; width of abdomen, 4.0 to 4.9 mm.

Color. In general appearance ranging from almost white to a very dark brown. Both color and pattern extremely variable. Colors present are red, brown, yellow, white, black, and green. Below, abdomen variable, from pale yellow to dark brown, but most specimens have the median area of abdomen darker than rest of specimen. Legs ringed with brown, front femora fre-

quently with rings expanded, fused and covering almost the basal two thirds of the femur, the fusion is not complete and there are spots of paler coloration present.

Structural characteristics. Apex of head rounded; front not at all rough; ocelli fairly large, larger than the blisterlike granules of the hemelytra. Disc of pronotum not very rough; lateral margin of pronotum subparallel for a distance about equal to ocellocular space, then extending diagonally posterolaterad to the lateral angle, this portion of lateral margin slightly convex; posterolateral margin nearly straight and converging to humeral angle of pronotum; lateral angle projecting beyond base of embolium; abdomen slightly wider than pronotum; base of pronotum lacking short, longitudinal carinae. Hemelytra extending beyond end of abdomen; membrane well developed; basal half of lateral margin of embolium slightly expanded, expansion equal to one fourth or one fifth of the ocellocular space, expansion rounded or obtusely angulate posteriorly. Connexivum usually slightly exposed, some males have the connexivum completely covered by the hemelytra. Blisterlike granules of the hemelytra few, small, less than width of base of hind tarsus. Spatulate right side of seventh ventral abdominal segment of male short, not extending to the lateral margin of the abdomen, partially covered by the preceding segment; left side only slightly projecting posteriorly. Female ventral abdominal segments symmetrical except for incision of posterior margin of last segment, which is strongly bent to the left. Keel hood of male genitalia rather long, mainly to the left side of keel, but covering most of apex; membranous secondary keel hood present and nearly as large as keel hood; fringe of keel hood with left side nearly transverse and slightly concave, right half extending almost anteriorly to right margin of keel; keel hook present, slender, recurved to base of pan; pan small, thick, rounded apically and apex provided with slight circular depression; right clasper hook, like that of *G. oculatus* (Fabricius) and *G. rotundatus* Champion, apical portion digitiform, transverse basal portion much wider, with distinct lateral projections at base of digitiform apex; tumescence of right clasper not adnate to basal portion of clasper; anterolateral projection of keel absent.

Location of type. In the Museum of Paris, Paris, France.

Distributional Data. The types are from Venezuela. Melin also examined specimens from Mexico, Guatemala, Nicaragua,

Costa Rica, Panamá and Colombia. Millspaugh reports this species from Texas, but the writer has not seen specimens from that state. Specimens available for study were from the following localities:

Mexico: Acapulco, Guerrero, Aug. 16-30, 1938, L. J. Lipovsky, 1 male; same place, Aug. 28, 1938, L. J. Lipovsky, 1 female; 10 mi. S Chilpancingo, Guerrero, June 23, 1932, H. Smith, 1 female; La Sabana, Guerrero, 226 km. S Mexico (city), Oct. 20, 1936, H. D. Thomas, 27 males and 25 females; Mexcala, Guerrero, Río Balsas, Dec. 14, 1928, Dampf., 5 males and 3 females; Rincón, Guerrero, 260 km. S Mex. City, Oct. 31, 1936, H. D. Thomas, 2 males and 2 females; Río Agua, Guerrero, 437 km. S Mexico (city), Oct. 31, 1936, H. D. Thomas, 16 males and 11 females; Guerrero, 438 km. S Mex. City, Nov. 1, 1936, H. D. Thomas, 3 males and 3 females; Sacacoyuca, Gro., 216 km. S Mexico (city), Oct. 31, 1936, H. D. Thomas, 3 males and 2 females; Tecolotlán, Jalisco, Sept. 14, 1938, L. J. Lipovsky, 1 female; Alpuyeca, Morelos, 102 km. S Mex. City, Oct. 15, 1936, H. D. Thomas, 19 males and 26 females; Río Amacuya, Morelos, 133 km. S Mexico (city), Oct. 14, 1936, H. D. Thomas, 7 males and 9 females; 5 mi S Valles, San Luis Potosí, June 13, 1932, H. Smith, 2 males and 3 females; Río Mayo, San Bernardo, Sonora, Oct. 14, 1934, H. S. Gentry, 2 females; Tejupilco, Dist. of Temascaltepec, June-July, 1933, H. E. Hinton, 2 males; Minatitlán, Vera Cruz, Sept. 22, 1936, H. D. Thomas, 1 male.

Guatemala: El Salto Escuintla, 1934, F. X. Williams, 1 male and 1 female; Gualán, Jan. 14, 1905, no collector (holotype of *G. cucullatus* Martin); same place, Jan. 4, 1905, no collector, 2 males and 2 females; Guatemala City, no date, Champion (1 male paratype of *G. cucullatus*); Los Amates, Jan. 16, 1905, no collector, 2 males and 1 female (paratypes of *G. cucullatus*); same place, no date, Kellerman (4 male paratypes of *G. cucullatus*).

Honduras: Copán, Feb. 18, 1937, C. Roys, 3 males and 2 females; Progreso, Feb. 23, 1936, J. Deal, 5 males and 4 females.

Nicaragua: "Nicaragua", O. Sacken., 1 male (AMNH); ?. O. Sacken. (1 male paratype of *G. cucullatus*) (AMNH).

Costa Rica: Río Torres, Feb. 10, 1932, H. Schmidt, 3 females; Río Virilla, Dec. 26, 1931, H. Schmidt, 55 males and 48 females; San José, June and July, 1931, H. Schmidt, 2 males and 2 females; San José, 1932, H. Schmidt, 16 males and 40 females.

Panamá: Barro Colorado, C. Z., July 13, 1924, N. Banks (1 female paratype of *G. cucullatus*) (MCZH); same place, Dec. 22, 1928, C. H. Curran, 1 male (AMNH); Caldera, Feb. 28, 1935, D. V. Brown, 38 males and 33 females; Cochea River, Mar. 6, 1935, D. V. Brown, 4 males and 3 females; Gamboa, C. Z., Apr. 2, 1921, J. G. Saunders, 4 males and 8 females; Progreso, Chiriquí Prov., Apr. 18, 1923, F. M. Gaige, 1 female; Pehonoma, 1926, H. Brown (allotype female of *G. cucullatus* Martin).

Colombia: Arroyo de Arenas, Sta. Marta Mts., July 25, 1920, F. M. Gaige, 1 male and 2 females (Mich. Coll.); Cuyaima Tolima, Nov. 9, 1944, R. A. Stirton, 1 female; Villavieja, 1944, R. A. Stirton, 3 females.

Comparative notes. Externally, very similar to *G. oculatus* (Fabricius), but considerably smaller than most specimens of the latter species. Easily separated by the presence of a large, membranous secondary keel hood on the male genitalia.

Gelastocoris vicinus Champion

(Pl. IV, fig. 17; Pl. VI, fig. 32)

1901. *Gelastocoris vicinus* Champion, Biologia Centrali-Americana, Rhynchota Heteroptera, vol. II, p. 349.
1906. *G. vicinus* Torre-Bueno, Ent. News, vol. XVII, p. 54.
1909. *G. vicinus* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 181.
1910. *G. vicinus* Montandon, Annuario del Museo Zoologico della R. Università di Napoli (nuova serie), vol. 3, no. 10, p. 2.
1910. *G. vicinus* Banks, Catalogue Nearctic Hemip.-Heteroptera, Am. Ent. Soc. (sep. publ.), p. 11.
1917. *G. vicinus* Van Duzee, Catalogue of Hemiptera N. America, Univ. California Publ., p. 473.
1929. *G. vicinus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 163-164, fig. 22.
1929. *G. vicinus* Martin, Univ. Kansas Sci. Bull. vol. XVIII, no. 4, pp. 362-363, pl. 58, fig. 7, pl. 59, fig. 9.
1939. *G. vicinus* Millspaugh, Field and Laboratory, vol. VII, no. 2, p. 88.

Size. Male: Length, 6.2 to 7.1 mm.; width of pronotum, 3.9 to 4.3 mm.; width of abdomen, 5.0 to 4.3 mm. Female: Length, 7.1 to 8.0 mm.; width of pronotum, 4.3 to 4.8 mm.; width of abdomen, 4.3 to 5.0 mm.

Color. In general appearance usually some shade of brown. Of approximately one hundred specimens, there is one that is light green and only three that are light brown or yellowish-brown. The black spot of the corium at the middle of the claval suture, as well as other black spots of the hemelytra, are conspicuous on most specimens. The color and patterns are variable to some extent, but not to the degree as in some of the other species. Colors present are

red, brown, black, yellow, green, and white, although the last two are not commonly found. Below, abdomen usually with lateral portions lighter than median portion, but abdomen as a whole lighter than upper surface of body, occasionally suffused with red. Legs ringed with dark brown, front femora indistinctly ringed, but this may vary to almost completely fused rings, the intensity of the brown also variable.

Structural characteristics. Apex of head rounded; front quite rough; ocelli rather large, one and one-half times size of largest blisterlike granules. Disc of pronotum rough; lateral margin subparallel for a distance equal to one and one-fourth times the width of the ocellocular space, slightly divergent posteriorly, then extending posterolaterad to lateral angle; posterolateral margin concave; width of pronotum subequal to width of abdomen; distinctly projecting laterad beyond the base of embolium; base of pronotum lacking short, longitudinal carinae. Hemelytra extending to or beyond the end of abdomen in both sexes; membrane well-developed; basal half of lateral margin of embolium expanded laterad, width of the expansion equal to one half the ocellocular space, expansion acute or obtusely angulate posteriorly. Connexivum visible in both sexes, but not too exposed. Blisterlike granules numerous, not very large, about equal in size to base of hind tarsus, many of the smaller ones more elevated, becoming peglike. Spatulate right side of seventh ventral abdominal segment of male short, not extending to lateral margin of the abdomen, about one-half covered by the preceding segment; left side moderately projecting posteriorly. Female ventral abdominal segments more or less symmetrical except that the incision of the posterior margin of the last segment is slightly bent to the left. Keel hood of male genitalia triangular, covering apex, fringe nearly transverse, following margin basad on left side of keel; keel hook present, fairly stout, not very recurved, but reaching margin of pan; pan short, more or less flattened and in an oblique plane in respect to the horizontal plane of the genital capsule; right clasper hook with digitiform apex, transverse basal portion very wide at base and narrowing rapidly to base of digitiform apex; tumescence of right clasper not adnate to basal portion of clasper; anterolateral projection of keel absent.

Location of type. In the British Museum at London, England.

Distributional data. In the original description Champion gives for the distribution of this species the following: "Habitat: North

America, southern and western United States; Mexico; Panama; South America to Brazil." This seems too great a range to the present writer, as he has not seen specimens from the United States or from South America. It seems likely that the records of specimens from these areas have been based upon misidentifications. The writer has studied specimens from the following localities:

Mexico: Colima, Vulcano, no date, L. Conrad, 1 female, compared with type by Doctor H. B. Hungerford; La Sabana, Guerrero, kil. 226 S Mex. City, October 20, 1936, H. D. Thomas, 1 female; Chiapas, Juárez, March 19, 1939, P. Brodkorb, 1 male (Mich. Coll.); Cuautla, Morelos, June 27, 1948, P. P. Dowling, 1 male (Mich. Coll); Tejupilco, Dist. of Temascaltepec, June-July, 1933, H. E. Hinton, 4 males; Nayarit, Tepic, March, 1923, no collector, 2 females (USNM); 5 mi. S Valles, San Luis Potosí, June 13, 1932, H. Smith, 1 female.

Guatemala: Los Amates, January 16, 1905, no collector, 2 females.

Honduras: Aguán R. valley, Copete farm, April 10, 1923, T. H. Hubbell, 1 female; Copán, February 18, 1937, C. Roys, 1 male; Tela, Guaimas Dist., May 10, 1923, T. H. Hubbell, 2 females.

Costa Rica: San José, June-July, 1931, H. Schmidt, 4 males and 6 females; same place, purchased 6, 1931, H. Schmidt, 2 females; same place, 1932, H. Schmidt, 5 males and 2 females; same place, no date, Heidemann, 2 males; R. Surubres, San Mateo, February, 1905, P. Biolley, 35 males and 29 females; Río Torres, February 10, 1932, H. Schmidt, 1 female; Río Virilla, December 26, 1931, H. Schmidt, 32 males and 18 females; Surrubres, no date, A. Heyne, 3 males and 5 females.

Panamá: Barro Colorado, July 31, 1924, N. Banks, 2 females (MCZH); Boquete, Chiriquí Prov., Mar. 2, 1923, F. M. Gaige, 1 female; Cochea River, Mar. 6, 1935, D. V. Brown, 1 female.

Isla de Pinos: Jan. 15, 1923, C. H. Ballou, 1 female.

Comparative notes. Similar to *G. oculatus* (Fabricius), but with the posterior portion of the lateral margin of the pronotum straighter and the lateral angle more angulate. Although the genitalia are similar to the genitalia of *G. oculatus* (Fabricius), there is one constant difference. The pan of this species is always in an oblique plane in respect to the horizontal plane of the genital capsule and the pan is more flattened. In his 1910 paper, Montandon places *G. vicinus* Champion in the synonomy of *G. quadrimaculatus* (Guérin-Méneville). The writer cannot accept Mon-

tandon's action in this matter. Montandon states that the type of *G. quadrimaculatus* (Guérin-Méneville) does not agree in coloration with the specimens he had previously identified as *G. vicinus* Champion. Coloration in itself is not generally considered of much value in the Gelastocorinae, yet in this case, it may be an indication that the type of *G. quadrimaculatus* (Guérin-Méneville) is not the same as *G. vicinus* Champion. The writer has not seen the pattern, as described by Montandon, in *G. vicinus* Champion. It is a common pattern in several other species, for example *G. oculatus* (Fabr.) and *G. nebulosus* (Guérin-Méneville). Montandon doubts the correctness of the locality label (Bolivia) of the type of *G. quadrimaculatus* (Guérin-Méneville). He states that the type agrees in form with specimens he had labelled *G. vicinus* Champion and which were from ". . . Cost Rica, Mexique, Perou (Mus. Nat. Hung. Budapest), Venezuela, Bresil (Mus. Senckenberg Frankfurt), Chulumani Bolivie (coll. Schouteden)." Montandon does not indicate that there was a similarity of a particular morphological structure, so we must assume that a general similarity of habitus prompted his action in placing *G. vicinus* Champion in the synonomy of *G. quadrimaculatus* (Guérin-Méneville). Further there is no evidence that he had material with him which he could have compared with the type of the latter species. The writer has seen no specimens of *G. vicinus* Champion from South America and he does not believe it occurs there, particularly in Bolivia. In this paper *G. quadrimaculatus* (Guérin-Méneville) is treated as a synonym of *G. nebulosus* (Guérin-Méneville). Those specimens which were from South America and which Montandon had formerly labelled *G. vicinus* Champion were probably a mixed series of several species. *G. fuscus* Martin, *G. amazonensis* Melin and *G. nebulosus* (Guérin-Méneville) may have been represented. The first two species both resemble *G. vicinus* Champion in general habitus. It is quite possible that *G. quadrimaculatus* (Guérin-Méneville) will prove to be an older name for *G. fuscus* Martin, provided that the type of the former was not destroyed during World War II and provided it can be located and examined.

Gelastocoris bufo (Herrich-Schäffer)

(Pl. IV, fig. 15; Pl. VI, fig. 34)

(1839) 1840. *Galgulus bufo* Herrich-Schäffer, Die Wanzenartigen Insecten, V, p. 88, pl. 174, fig. 536.
1873. *G. bufo* Walker, Catalogue of Hemiptera in the British Museum, part VIII, p. 171.

1876. *G. bufo* Uhler, Bull. U. S. Geol. Surv., vol. I, no. 5, p 337.
1876. *G. bufo* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, no. 4, p. 137.
1895. *G. bufo* Pittier and Biolley, Instituto fisico Geografico Nacional (Costa Rica), p. 23.
1901. *Gelastocoris bufo* (Herrich-Schäffer); Champion, Biologia Centrali-Americana, Rhynchota Heteroptera, vol. II, p. 348, pl. XX, fig. 16.
1906. *G. bufo* Torre-Bueno, Ent. News, vol. XVII, p. 54.
1909. *G. bufo* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 180.
1929. *G. bufo* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 156-158, fig. 11.
1929. *G. bufo* Martin, Univ. Kansas Sci. Bull., vol. XVIII, no. 4, p. 360, pl. 58, fig. 14.

Size. Male: Length, 7.0 to 8.0 mm.; width of pronotum, 4.1 to 4.6 mm.; width of abdomen, 4.4 to 4.9 mm. Female: Length, 8.1 to 8.8 mm.; width of pronotum, 4.7 to 5.3 mm.; width of abdomen, 4.8 to 5.5 mm.

Color. Variable, from pale yellow to black in general appearance. The main colors present are brown, red, yellow and black; a few specimens show some green coloration, but white is rarely found, except on some specimens, where it is limited to the blisterlike granules of the hemelytra. The pattern is as variable as the colors. Below, with the abdomen dark brown, legs annulated with dark brown, front femora with the basal two thirds, except for a small yellow spot on the anterior margin at the middle, entirely dark brown.

Structural characteristics. Apex of head rounded; front slightly elevated and moderately rough; ocelli small, subequal to the blisterlike granules of the hemelytra in size, located on very small tubercles between the eyes. Pronotum with the disc moderately rough; lateral margin of pronotum slightly concave, extending posterolaterad to the lateral angle; posterolateral margin nearly straight, extending posteromesad to humeral angle, forming a right angle with the lateral margin; not quite as wide as abdomen; lateral angle projecting beyond the base of embolium; base of pronotum lacking short, longitudinal carinae. Hemelytra extending beyond the end of the abdomen in both sexes; membrane well developed; basal half of lateral margin of embolium slightly expanded, width of expansion equal to one third of ocellocular space, expansion posteriorly very obliquely rounded, tapering into margin of posterior half of embolium. Connexivum visible in both sexes. Blisterlike granules very small, fairly numerous, two thirds width of base of hind tarsus in size. Spatulate right side of seventh ventral abdominal segment of male only slightly covered by the preceding segment, not extend-

ing to the lateral margin of the abdomen; left side projecting posteriorly only slightly. Female ventral abdominal segments nearly symmetrical. Keel hood of male genitalia broadly triangular, one-third to one-fourth as long as wide, fringe transverse, slightly concave; keel, just basad of keel hood, broadly expanded to the right; keel hook present, rather large, not recurved and apex not extending over any portion of pan; pan rather broad, cup-shaped due to large depression; right clasper hook similar to that of *G. oculatus* (Fabricius), apical half, thin, digitiform, transversal portion much thicker and increasing in width toward base; tumescence of right clasper not adnate to basal portion of right clasper; anterolateral projection of keel absent.

Location of type. Unknown. Other Hemipterous insects of the collection of Herrich-Schäffer are located in the Museum of München, München, Germany.

Distributional data. The original description merely states: "Aus Amerika." Champion and Martin examined specimens from Mexico, Guatemala and Costa Rica. Melin studied specimens from these localities and from Panamá. This worker has seen specimens from the following localities:

Mexico: Cocula, Jalisco, November, 1923, no collector, 1 female (USNM); El Sabino, Uruapan, Mich., July 20, 1936, H. D. Thomas, 2 females; same place, August 2, 1936, H. D. Thomas, 1 female; Las Barrancas, March, 1923, W. M. Mann, 1 female (USNM); San Antonio, Nr. El Salto, June 10, 1937, M. Embury, 18 males and 16 females; Real de Arriba, Dist. of Temascaltepec, May-June, 1933, H. E. Hinton, 25 males and 29 females; Tejupilco, Dist. of Temascaltepec, June-July, 1933, H. E. Hinton, 3 males and 4 females.

Guatemala: El Salto Escuintla, 1934, F. X. Williams, 1 male; Guatemala City, no date, Champion, 1 male; Alta Vera Paz, Dept. Baja, no date or collector, 1 female (MCZH); "Guatemala," no date or collector, 1 female (MCZH).

Costa Rica: Río Virilla, December 26, 1931, H. Schmidt, 2 males and 5 females; San José, June and July, 1931, H. Schmidt, 1 female; same place, purchased June, 1931, H. Schmidt, 1 male; same place, 1932, H. Schmidt, 1 female.

Panamá: Cochea River, March 6, 1933, D. V. Brown, 1 male.

Comparative notes. This species is distinguished from most species by the lateral margin of the pronotum being nearly straight. It is easily separated from *G. angulatus* (Melin) since this species

lacks the short, longitudinal carinae of the pronotum and the genitalia are quite different. The male genitalia are rather similar to those of *G. oculatus* (Fabricius), but the pan is more flattened and shorter than in that species.

Two references have not been included in the bibliography of this species because it is not possible to determine whether they actually refer to this species or not. The first of these papers is that of Spinola (Essai sur les Insects Hémiptères, etc., Genes, 1837, p. 62). Spinola uses the name *Galgulus bufo* Lefebvre and adds this statement: "Nouvelle espèce qui m'a été envoyée par M. Lefebvre." I have been unable to find a paper by Lefebvre in which this species is described. The name apparently was a manuscript name of Lefebvre's and it is a *nomen nudum* in Spinola, since he did not describe or figure the species. Herrich-Schäffer also credits the species to Lefebvre, but it is quite possible that he was following Spinola. He states: "Da ich diese einzige Art dieser Gattung vor mir habe, so kann ich nicht mit Bestimmtheit behaupten, ob es wirklich Lefebvre's Bufo ist." It is therefore possible that Herrich-Schäffer did not have the same species before him as that before Spinola. Herrich-Schäffer did not describe the species, but he did figure it and therefore becomes the author. The second paper omitted from the bibliography of this species is that of Dohrn (Catalogus Hemipterorum, 1859, p. 53). Dohrn also lists this name with Lefebvre as the author. He may have been following either Spinola or Herrich-Schäffer.

Gelastocoris amazonensis Melin

(Pl. V, fig. 22; Pl. VI, fig. 36)

1929. *Glastocoris amazonensis* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 158, figs. 1, 3, 12.

Size. Male: Length, 7.9 to 8.2 mm.; width of pronotum, 4.6 to 4.9 mm.; width of abdomen, 4.6 to 4.9 mm. Female: Length, 7.5 to 8.6 mm.; width of pronotum, 4.8 to 5.0 mm.; width of abdomen, 5.0 to 5.1 mm.

Color. In general appearance brown to reddish-brown, nearly concolorous, the lateral portions of the pronotum slightly lighter than the disc, occasionally with darker areas along the lateral margins of the hemelytra. Colors present are mainly brown, red and black. Below, dark brown, legs lighter, ringed with dark brown. Blisterlike granules of the hemelytra are very pale green in two specimens, light or dark brown in the others.

Structural characteristics. Apex of head rounded; front rather

rough; ocelli large, nearly twice the size of the blisterlike granules. Disc of pronotum rather rough; lateral margin approaching that of *G. bufo* (Herrich-Schäffer), but a little more notched, margin extending diagonally, more posteriorly than laterally, for a distance equal to one and one-half times the ocellocular space, then proceeding posterolaterad to the lateral angle, usually there is a small triangular projection on the anterior one third of the lateral margin, this projection is smaller than a similar projection in *G. fuscus* Martin; posterolateral margin straight slightly concave, extending from the lateral margin at almost a right angle, the posterolateral margin is more convergent than in *G. fuscus* Martin; pronotum and abdomen about equal in width, the body rather elongate in appearance; lateral angle projecting laterad beyond base of embolium; base of pronotum lacking short, longitudinal carinae. Hemelytra extending to or beyond the end of the abdomen; membrane well-developed; basal half of lateral margin of embolium slightly expanded, the expansion equal to one third the width of the ocellocular space, margin weakly serrate, expansion acutely angulate posteriorly. Connexivum visible in both sexes, moderately expanded laterally, blisterlike granules of hemelytra small, fairly abundant, rather elevated, subconate, about one-half the width of base of hind tarsus in size. Spatulate right side of seventh ventral abdominal segment of male short, not extending to the lateral margin of the abdomen, oval in shape, nearly covered by the preceding segment; left side moderately projecting posteriorly. Female ventral abdominal segments symmetrical, incision of the posterior margin of the last segment rather broad. Keel hood of male genitalia crescent-shaped, fringe nearly transverse, concave; keel hook present, rather slender and not very recurved; pan flat with elongate apex which is twisted completely around; right clasper hook, simple, more or less sickle-shaped; tumescence of right clasper not adnate to basal portion of clasper; anterolateral projection of keel absent.

Location of type. In the Museum of Stockholm, Stockholm, Sweden.

Distributional data. Known only from Amazonas, Brazil. Melin studied specimens from Rio Autaz, Amazonas, Oct., A. Roman, holotype male, allotype female and 1 male paratype; Rio Negro, Umarituba, Amazonas, Apr. 28, A. Roman, 3 males and 3 females (paratypes); and Tefé, Amazonas, 1 male and 1 female paratypes. This writer has seen all the specimens from the first locality and 3 female paratypes from the second locality.

Comparative notes. Resembling *G. fuscus* Martin and *G. bufo* Herrich-Schäffer, but a more slender species than either of these. The worker has examined the genitalia of the holotype and of the male paratype from Rio Autaz. They are identical and extremely different from all other species. The pan is elongate, thin and twisted completely over.

Gelastocoris major Montandon

(Pl. V, fig. 21; Pl. VI, fig. 39)

1910. *Gelastocoris major* Montandon, Annuario del Museo della R. Università di Napoli (Nuova Serie), vol. 3, no. 10, p. 2.
1952. *G. major* Hussey, Florida Entomologist, vol. XXXV, no. 2, pp. 69-70.

Also referring to this species:

1929. *Gelastocoris andinus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 159-160, fig. 14.
1929. *Gelastocoris duplicatus* Martin, Univ. Kansas Sci. Bull., vol. XVIII, no. 4, p. 364, pl. 58, fig. 17, pl. 59, fig. 7.

Size. Male: Length, 6.8 to 8.0 mm.; width of pronotum, 3.8 to 4.7 mm; wide of abdomen, 4.4 to 5.1. mm. Female: Length, 7.4 to 8.8 mm.; width of pronotum, 4.4 to 4.9 mm.; width of abdomen, 5.0 to 5.8 mm.

Color. In general appearance ranging from light brown to black, both color and pattern are quite variable. Colors present are yellow, orange, brown, black and green, but the latter is in the blisterlike granulations of the hemelytra. Below, with the abdominal segments lighter laterally; legs ringed with brown, the intensity depending directly upon the darkness of the individual specimen.

Structural characteristics. Apex of the head rounded; or slightly pointed; front of head with moderate elevations; ocelli small, about one-half to three-fourths the size of the largest blisterlike granules. Pronotum with the disc moderately rough; lateral margin with anterior portion subparallel, but convex, for a distance equal to two thirds the length of the ocellocular space, then lateral margin preceding posterolaterad to the lateral angle, lateral margin very faintly serrate to smooth; posterolateral margin converging very slightly to the humeral angle of the pronotum, serrate; lateral angle projecting laterad only slightly beyond base of embolium; width of pronotum less than width of abdomen; base of pronotum lacking short, longitudinal carinae. Hemelytra of males extending to end of abdomen, in females hemelytra may reach end of abdomen or may be slightly shorter; membrane greatly reduced, limited to a narrow strip around the apex and extending along inner margin to

claval suture; basal half of lateral margin of embolium expanded slightly, about the width of blisterlike granule, expansion posteriorly may be either angulate or broadly rounded. Connexivum barely visible in the males, more evident but not prominent in the females. The blisterlike granules fairly numerous, largest subequal in width to width of hind tarsi. Seventh ventral abdominal segment of male with spatulate right side nearly covered by sixth segment and not reaching the lateral margin of the abdomen; left side projecting posteriorly only slightly. Female ventral abdominal segments nearly symmetrical, the incision may be bent slightly to the left. Male genitalia very distinctive; keel hood rounded, broad, crescent-shaped, fringe of long hairs, extending transversely then basally along right margin of keel; keel hook absent, replaced by two very heavily sclerotized, broadly triangular projections; pan very distinctive, bilobed; right clasper hook short, sickle-shaped, very broad at base, but rapidly narrowing; tumescence of right clasper not adnate to basal portion of clasper; anterolateral projection curved mesad, bluntly claw-shaped.

Location of type. Unknown. The matter of a type of this species requires a discussion of the description of the species. Montandon had misidentified this species in routine identification as *G. flavus* (Guérin-Méneville). When he examined the type of the latter species he realized his error and described "G. MAJOR Montand. nov. sp. = *G. flavus* Montand. *olim*, (nec Guérin) et Champion *Biol. Cent. Am.* 2, p. 349, . . ." Montandon did not indicate a type in the description. In the discussion of "*Gelastocoris nebulosus* Guérin *loc cit.* = *G. flavus* Guer. loc. cit." he does list some of the specimens which he had labelled *G. flavus* (Guérin-Méneville) and mentions where they were located. In this discussion he states that part of those he had labelled *G. flavus* (Guérin-Méneville) were from Chandra Maja, Pèrou and were in his personal collection. He also states that he had distributed many specimens from the above locality to the Museum of Naples and to many correspondents. If he did mark a specimen as a type, it may be in the British Museum, or it may have been in the collection of the University of Naples. There are four specimens in the collection of the United States National Museum which bear the label "*Gelastocoris major* Montd., Det. Montd. 1909." These specimens are the same species as *G. andinus* Melin, so it would appear that the latter specific name will fall as a synonym of *G. major* Montandon. Montandon places the *G. flavus* of Champion as this species, but it could also be the species

herein described as *Gelastocoris viridis* n. sp. Contrary to Hussey's statement, Melin did not propose *Gelastocoris andinus* to replace *G. flavus* Champion, 1901, *nec* Guérin-Méneville.

Distributional data. It would seem that if Montandon actually had material before him when he described this species it was probably specimens from Chandra Maja, Pèrou. The four specimens (2 males and 2 females) which Montandon labelled *G. major* Montd. are from Cachabe (Cachabi), Ecuador. In addition to the four specimens mentioned above, the writer has seen specimens from the following localities:

Ecuador: Naranjapata, Dec. 14, 1933, F. X. Williams, holotype male and allotype female (*G. duplicatus* Martin); Cachabi, no date, Rosenberg, 1 male.

Colombia: Bogotá, no date, Lindig, holotype male, allotype female, 2 male and 3 female paratypes (*G. andinus* Melin); Mt. San Lorenzo, Santa Marta Mts., June 8, 1920, F. M. Gaige, 6 males and 2 females (Mich. Coll.); same place, June 12, 1920, F. M. Gaige, 1 male and 1 female, (Mich. Coll.); same place, June 29, 1920, F. M. Gaige, 1 male and 4 females, (Mich. Coll.); same place, Aug. 17, 1920, F. M. Gaige, 1 male, (Mich. Coll.); Sasaima, Dec., 1936, A. Maria, 1 male and 1 female; Valle de Tabacal, Santa Marta Mts., Sept. 2, 1920, F. M. Gaige, 1 female, (Mich. Coll.).

Panamá: Gamboa, C. Z., Feb. 14, 1921, J. G. Sanders, 1 male; Ft. Clayton, C. Z., 1933, Cpt. R. F. Edwards, 1 female; Canal Zone, Mar. 19, 1945, Cpl. G. S. Ryan, 1 male and 2 females.

Comparative notes. Easily separated from all other species by means of the bilobed pan of the male genital capsule.

Gelastocoris peruensis Melin

(Pl. V, fig. 26; Pl. VI, fig. 38)

1929. *Gelastocoris andinus peruensis* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 160-161, figs. 4, 15,

Size. Male: Length, 7.7 to 8.4 mm.; width of pronotum, 4.4 to 4.8.; width of abdomen, 5.1 to 5.6 mm. Female: Length, 8.6 to 10.0 mm.; width of pronotum, 4.7 to 5.5 mm.; width of abdomen, 5.7 to 6.4 mm.

Color. Nearly concolorous, in general appearance various shades of brown, usually reddish-brown. Legs usually slightly lighter than body, and faintly ringed with brown, the dorsal surface of the legs particularly, often suffused with red.

Structural characteristics. Apex of head rounded to slightly

pointed; front not very rough, nearly flat; ocelli on the anterolateral surface of small elevations, very small, about three fourths width of largest blisterlike granules in size. Pronotum with the disc not very rough; lateral margin of pronotum subparallel for a distance equal to one and one fourth the ocellocular space, slightly diverging posteriorly, then extending obliquely posterolaterad for a short distance to lateral angle; posterolateral margins more or less subparallel, usually very slightly converging posteriorly or with entire margin convex; lateral angle scarcely projecting laterad beyond the base of the embolium; abdomen distinctly wider than the pronotum; base of pronotum lacking short, longitudinal carinae. Hemelytra extending to end of the abdomen; membrane greatly reduced, limited to thin strip around apex and extending along inner margin to claval suture; basal half of lateral margin of embolium scarcely expanded, width of expansion equal to one eighth of ocellocular space, expansion posteriorly usually running smoothly into margin of posterior half of embolium or very weakly obtuse. Connexivum almost completely hidden in the males, a little more obvious in females, not at all prominent. Blisterlike granules rather small, but numerous, about equal in width to base of hind tarsus. Spatulate righ side of seventh ventral abdominal segment of male short, rounded, only slightly covered by preceding segment, not extending to lateral margin of abdomen; left side only slightly projecting posteriorly. Female ventral abdominal segments more or less symmetrical, incision of posterior margin of last segment broad. Keel hood of male genitalia semicircular, broad, sclerotized overfold not very long, fringe long and extending completely across apex and down the right side of keel; keel hook short, not prominent, greatly modified, forming a heavily sclerotized roof over the base of the pan; pan elongate, rather flat; tumescence of right clasper not adnate to basal portion of clasper; right clasper hook curved, wide basally and tapering to a thin point apically, apical portion sickle-shaped; anterolateral projection of keel present, slender, clavate and bent mesad.

Location of type. In the Museum of Stockholm, Stockholm, Sweden.

Distributional data. Apparently restricted to Perú. The writer has examined specimens from the following localities in Perú: Roque, nr. Moyobamba, March 31, D. Melin, holotype female, 4 male and 1 female paratypes (Mus. of Stockholm); same place, Sept. 8, D. Melin, 1 male paratype (Mus. of Stockholm); Chandra

Maya, no date or collector, 2 males and 1 female; Prov. La Mar. Sivia, Dept. Ayacucho, June 16-20, 1941, F. Woytkowski, 22 males and 17 females; Río Perené and Río Chanchosmayo, Dept. Junín, May, 1934, F. Woytkowski, 6 males and 6 females; Loc Shapajilla, Dept. Huanuco, July 29 to August 10, 1938, F. Woytkowski, 1 female; Marcopata, no date or collector, 8 males and 10 females; Río Paucartambo, Quiroz, Dept. Junín, January, 1934, G. Nelson, 3 females; Tambo, Enenas Cam. del Pichis, July 3, 1920, Corn. Univ. Ex., 1 male; Rioja, Dept. San Martín, September 9 to October 3, 1936, F. Woytkowski, 2 males and 4 females; San Pedro, May 15-19, 1935, F. Woytkowski, 3 males; same place, May 29, 1935, F. Woytkowski, 8 males and 5 females; Sani Beni, River Sani Beni, September 5, 1935, F. Woytkowski, 3 males; "Peru," 1937, F. Woytkowski, 22 males and 25 females.

Comparative notes. Similar to *G. nebulosus* (Guérin-Méneville) but generally larger and easily distinguished by the male genitalia. The genitalia show the close relationship to *G. major* Montandon (*G. andinus* Melin). The writer has removed the name of *G. peruensis* Melin from the position of a subspecies of the latter species and has raised it to specific status.

Gelastocoris nebulosus (Guérin-Méneville)

(Pl. V, fig. 24; Pl. VI, fig. 35)

1844. *Galgulus nebulosus* Guérin-Méneville, Iconographie du Règne Animal de B. Cuvier, pt. 7, pp. 351-352.
1859. *G. nebulosus* Dohrn, Catalogus Hemipterorum, p. 53.
1876. *G. nebulosus* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, no. 4, p. 137.
1879. *G. nebulosus* Berg, Hemiptera Argentina, p. 184.
1909. *Gelastocoris nebulosus* (Guérin-Méneville); Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 180.
1910. *G. nebulosus* Montandon, Annuario del Museo Zoologico della R. Università di Napoli (nuova serie), vol. 3, no. 10, p. 2.

Also referring to this species:

1844. *Galgulus flavus* Guérin-Méneville, Iconographie du Règne Animal de B. Cuvier, pt. 7, p. 351, pl. 57, figs. 4, 4a.
1859. *G. flavus* Dohrn, Catalogus Hemipterorum, p. 53.
1909. *Gelastocoris flavus* (Guérin-Méneville); Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 180.
1929. *G. flavus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 161-162, figs. 2, 16-20.
1954. *G. flavus* DeCarlo, Mision de Estudios de Patologia Regional Argentina, ano XXIV, numeros 83-84, pp. 88-90, figs. 1, 7.
1876. *Galgulus nebulosus* var. *b.* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, no. 4, p. 137.
1909. *Gelastocoris stali* Torre-Bueno, *in* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 180 (named Stål's var. *b*).
1929. *G. quadrimaculatus* Martin, Univ. Kans. Sci. Bull., vol. XVIII, no. 4, pp. 361-362, pl. 58, figs. 1-5; pl. 59, figs. 14-16.

1954. *Gelastocoris paraguayensis* DeCarlo, Mision de Estudios de Patologia Regional Argentina, ano XXIV, numeros 83-84, pp. 90-92, figs. 2, 8.
1954. *Gelastocoris bolivianus* DeCarlo, Mision de Estudios de Patologia Regional Argentina, ano XXIV, numeros 83-84, pp. 92-94, figs. 3, 9.
1954. *Gelastocoris vianai* DeCarlo, Mision de Estudios de Patologia Regional Argentina, ano XXIV, numeros 83-84, pp. 94-95, figs. 4, 10.
1954. *Gelastocoris bergi* DeCarlo, Mision de Estudios de Patologia Regional Argentina, ano XXIV, numeros 83-84, pp. 96-97, figs. 5, 11.

Possibly referring to this species:

1844. *Galgulus quadrimaculatus* Guérin-Méneville, Iconographie du Règne Animal de G. Cuvier, part 7, p. 351.
1859. *G. quadrimaculatus* Dohrn, Catalogus Hemipterorum, p. 53.
1876. *G. quadrimaculatus* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, no. 4, p. 137.
1909. *Gelastocoris quadrimaculatus* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 180.
1910. *G. quadrimaculatus* Montandon, Annuario del Museo Zoologico della R. Università di Napoli (nuova serie), vol. 3, no. 10, p. 2.

Size. Male: Length, 5.5 to 8.0 mm.; width of pronotum, 3.7 to 4.6 mm.; width of abdomen, 4.2 to 5.3 mm. Female: Length, 6.4 to 8.8 mm.; width of pronotum, 4.0 to 5.4 mm.; width of abdomen, 4.3 to 6.3 mm.

Color. Quite variable, ranging from light brown to black. Both colors and patterns extremely variable. Colors present may be brown, black, orange, green, yellow and red. Blisterlike tubercles of the hemelytra variable in color, orange, white, green, brown and black. Legs pale green to reddish-brown, ringed with brown, although the distinctness of the rings varies with the specimen.

Structural characteristics. Apex of head pointed or very narrowly rounded; front slightly to moderately rough; ocelli fairly large, subequal to width of blisterlike granules in size. Disc of pronotum rather rough; lateral margin subparallel for a distance equal to two and one-half times the ocellocular space, then extending posterolaterad for a short distance to lateral angle; posterolateral margin straight, short, either subparallel or converging posteriorly; abdomen in specimens from Perú and Ecuador distinctly wider than pronotum, those from Brazil have the pronotum a little wider, but still less than width of abdomen; lateral angle scarcely projecting laterad of base of embolium; base of pronotum lacking short, longitudinal carinae. Hemelytra extending to or beyond end of abdomen in males, extending to end of abdomen in females; membrane well developed or reduced depending upon where the specimen was taken, those from Perú and Bolivia have the membrane reduced to about one half its normal length; basal half of lateral margin of embolium distinctly expanded laterally, the expansion about one half the width of the ocellocular space, expansion obtusely

angulate posteriorly. Connexivum not very visible, but not completely covered by the hemelytra. Blisterlike granules numerous, equal to or slightly larger than width of base of hind tarsus. Spatulate right side of seventh ventral abdominal segment of male large, but not extending to the lateral margin of the abdomen, only slightly covered by the preceding segment; left side only slightly projecting posteriorly. Female ventral abdominal segments symmetrical, incision of the posterior margin of the last segment very broad. Keel hood of male genitalia short, crescent-shaped, fringe transverse, concave; keel hook present, greatly recurved, extending completely back across base of pan; pan more or less flat, wider than long and truncate or slightly rounded apically; right clasper hook large, with rather large lateral projection which gives the clasper a footlike appearance; tumescence of right clasper adnate to base of clasper; anterolateral projection of keel absent.

Location of type. Unknown. The type was in the Museo Zoologico della R. Università di Napoli, Italy, which was destroyed during World War II. The writer is unable to state whether the type survived the war.

Distributional data. Guérin-Méneville's type was from Brazil. This species has also been reported from Perú, Ecuador, Venezuela, Bolivia and Argentina. The writer has seen specimens from the following localities:

Brazil: Abama, no date, Mann, 1 female (MCZH); Alto Paraná, Mar. 1929, F. Schade, 1 female; Ariro Angra dos Reis, Estado do Rio, Mar. 28, 1948, A. L. de Carvalho, 6 males and 7 females; same place, May 29, 1948, A. L. de Carvalho, 17 males and 18 females; Campinas, Estado do São Paulo, Mar. 10, 1924, F. X. Williams, 1 female; Campo Gde., São Paulo, no date or collector, 1 male and 1 female; Espírito Santo, no date or collector, 1 male and 3 females; Kabelstation, Sept. 25, 1938, Geyskes, 1 female; Lassance, Minas Ger., Nov. 9-19, 1919, R. G. Harris, 1 male and 1 female; Nova Teutonia, Bauru, May, 1947, F. Plaumann, 19 males and 9 females; Nova Teutonia, Marilia, Apr., 1947, F. Plaumann, 1 male and 1 female; Nova Teutonia, Tupan L. 1, Apr. 1947, F. Plaumann, 31 males and 23 females; Nova Teutonia, Tupan L. 2, May 1947, F. Plaumann, 6 males and 9 females; Pará, Aug. 4, 1915, H. S. Parish, 1 female; Rezendo, Estado do Rio, Feb. 29, 1924, F. X. Williams, 1 female; Salfada, Cruzes, Oct. 5, 1908, no collector, 1 male (Car. Mus.); São Paulo, Oct., 1947, F. Plaumann, 1 female; Zanderij, I, Boven Pará Dist., Apr. 23, 1927, no collector, 1 female.

Paraguay: Albovena, Srojozuas, Nov. 16, 1926, F. Schade, 4 males and 7 females.

Venezuela: S. Esteban, Carbobo, Feb. 5, J. and E. B. Williamson, 1 male and 1 female (Mich. Coll.).

Ecuador: Tena, Apr. 13, 1923, F. X. Williams, 1 female.

Perú: Aguaitia, Dept. Loreto, Sept., 1946, F. Woytkowski, 1 male; Boquerón de Padre, Abad. Cordillera, Dept. Loreto, Aug. 3, 1946, F. Woytkowski, 1 male and 2 females; same place, Aug. 31, 1946, F. Woytkowski, 3 males and 1 female; Callanga, no date or collector, 1 male and 2 females; Prov. La Mar. Sivia, Dept. Ayacucho, June 16-20, 1941, F. Woytkowski, 1 male and 3 females; Loc Shapajilla, Dept. Huánuco, July 29 to Aug. 10, 1938, F. Woytkowski, 1 female; Río Perene, El Campamiento, June 18, 1920, Corn. Univ. Ex., 1 male and 1 female; Marcopata, no date or collector, 1 male; Puerto Bermúdez, Río Pichis, July 13-19, 1920, Corn. Univ. Ex., 1 male and 3 females; Río Paucartambo, Quiroz, Dist. Junín, Jan. 1934, G. Nelson, 4 males and 3 females; Río Perené and Chanchamago, Dept. Junín, May 1934, F. Woytkowski, 4 males; Tumaturmari, Aug., 1913, B. G., 3 males (AMNH); Satipo, Dec., 1942, P. Papryzki, 1 female; same place, July, 1942, P. Papryski, 1 male; Rioja, Dept. San Martín, Sept. 9 to Oct. 3, 1936, F. Woytkowski, 1 female; Río Negro, Nov. 4, 1935, F. Woytkowski, 1 female; Sani Beni, Río Sani Beni, Aug. 5, 1935, F. Woytkowski, 1 male and 2 females; same place, Sept. 5, 1935, F. Woytkowski, 6 females; San Pedro, May 15-19, 1935, F. Woytkowski, 9 males and 11 females; same place, May 29, 1935, F. Woytkowski, 4 males and 9 females; "Peru," 1937, F. Woytkowski, 2 males and 1 female.

Bolivia: Santa Cruz, no date, J. Steinbach, 42 males and 44 females; Sud Yungas, Dept. de La Paz, Sept., 1938, A. M. Olalla, 1 male; "Bolivia," no date or collector, 1 female.

Chile: Santiago, Aug. 26, 1949, L. E. Peña, 6 males.

Comparative notes. Similar to *G. peruensis* Melin, especially in the case of specimens with the membrane of the hemelytra reduced. It may be separated from the latter species by the characteristic genital capsule, which has the keel hook recurved completely back across the base of the pan and which has the tumescence of the right clasper adnate to the base of the clasper. The shape of the lateral margin of the pronotum will distinguish it from most other species.

Galgulus flavus, G. quadrimaculatus and *G. nebulosus* were de-

scribed in that order by Guérin-Méneville. The descriptions were based entirely upon coloration and only the first named species was figured. Martin, 1929, used *Gelastocoris flavus* (Guérin-Méneville) for the species known as *Gelastocoris angulatus* (Melin). He apparently thought that *G. flavus* (Guérin-Méneville) had the lateral margin of the pronotum like that of *G. bufo* (Herr.-Schäff.) but the figure of the species in Guérin-Méneville's paper shows that this is not the case. Martin used the name *Gelastocoris quadrimaculatus* (Guérin-Méneville) for this species. Stål, 1876, used *G. nebulosus* (Guérin-Méneville) in spite of the facts that *G. flavus* (Guérin-Méneville) has line priority and that it is the only species figured. Montandon, 1910, also used *G. nebulosus* (Guérin-Méneville) but probably because he had misidentified so many specimens under the name of *G. flavus* (Guérin-Méneville). Melin, to revise the genus, used the latter name. The present writer considered Melin to be "the first reviser" and in past years has determined many specimens under this name. However, the International Committee on Zoological Nomenclature has defined "the first reviser" and under this definition Stål, not Melin, becomes the first reviser and the name *G. nebulosus* (Guérin-Méneville) should be used.

Gelastocoris quadrimaculatus (Guérin-Méneville) possibly should not be placed in the synonymy of this species (see the discussion under *G. vicinus* Champion).

It has been necessary to place *Gelastocoris bergi* DeCarlo, *G. vianai* DeCarlo, *G. bolivianus* DeCarlo and *G. paraguayensis* DeCarlo in the synonymy of *Gelastocoris nebulosus* (Guérin-Méneville). DeCarlo based these names on slight variations of the lateral margins of the pronotum, of the granulations of the corium and of the male genitalia. This writer believes that these differences are only individual variations. The illustrations of the male genitalia of the species described by DeCarlo are all those of *G. nebulosus* (Guérin-Méneville). The illustrations show the foot-shaped right clasper hook and the adnate condition of the tumescence of the right clasper and the base of the right clasper. The details of the keel are not shown and therefore the very characteristic keel hook may not be identified. If DeCarlo had had before him all the species of the genus, more material of this species from other South American localities and all the literature pertaining to the genus, particularly the paper by Martin, 1928, perhaps he would not have proposed the above names.

Gelastocoris fuscus Martin

(Pl. V, fig. 20; Pl. VI, fig. 40)

1929. *Gelastocoris fuscus* Martin, Univ. Kansas Sci. Bull., Vol XVIII, No. 4, p. 364, Pl. 58, fig. 15, Pl. 59, fig. 17, 19a, 19b.

Also referring to this species:

1954. *Gelastocoris martinezi* DeCarlo, Mision de Estudios de Patologia Regional Argentina, ano XXIV, numeros 83-84, pp. 97-98, figs. 6, 12.

Size. Male: Length, 7.3 to 8.2 mm.; width of pronotum, 4.6 to 5.0 mm.; width of abdomen, 4.7 to 5.3 mm. Female: Length, 8.4 to 9.5 mm.; width of pronotum, 5.1 to 5.8 mm.; width of abdomen, 5.3 to 6.0 mm.

Color. In general appearance from pale to dark brown. Colors present are yellow, brown, black and green. The ground color is usually some shade of brown and there are patches of green and black on the hemelytra, but these patches are usually indistinct. In three specimens there is a yellow transverse band on the posterior portion of the pronotum, but this is not characteristic of this species as several others often exhibit this pattern of coloration. In about one half of the specimens studied the tibiae and tarsi were green while the basal portions of the legs were yellow or yellow-brown in color.

Structural characteristics. Apex of head rounded; front moderately rough; ocelli small, less than width of the largest blisterlike granules in size. Disc of pronotum not very rough; lateral margin of pronotum subparallel for a distance equal to the ocellocular space, this portion has a small triangular lateral projection, then the margin extends posterolaterad to lateral angle; the posterolateral margin straight or slightly concave, forming a right angle with the lateral margin; lateral angle projecting laterad beyond the base of the embolium; abdomen slightly wider than the pronotum; base of the pronotum lacking short, longitudinal carinae. Hemelytra extending to or beyond the end of the abdomen; membrane well developed; basal half of the lateral margin of the embolium only slightly expanded laterally, the expansion equal to one-sixth the width of the ocellocular space, expansion obtusely angulate or rounded posteriorly. Connexivum visible in both sexes, but more so in the females than in the males. Blisterlike granules of the hemelytra moderate in size, not over two thirds the width of the base of the hind tarsus, not very numerous. Spatulate right side of seventh ventral abdominal segment of male short, more or less ovate, not extending to the lateral margin of the abdomen, nearly

hidden by the preceding segment; left side moderately projecting posteriorly. Female ventral abdominal segments nearly symmetrical, the incision of the posterior margin of the last segment rather broad. Keel hood located to the right side of the keel, fringe extending from near apex of keel to a point near the tip of the keel hook, keel hook present, rather stout, scarcely recurved; pan longer than wide, rounded apically, rather stout; right clasper hook, slender, fairly long, simple and sickle-shaped; tumescence of right clasper not adnate to base of clasper; anterolateral projection of keel absent.

Location of type. In the Francis Huntington Snow Entomological Collection at the University of Kansas, Lawrence, Kansas.

Distributional data. Martin had specimens from Ecuador and Brazil before him, when he described this species. This worker has examined specimens from the following localities:

Ecuador: Baños, Jan. 22, 1923, F. X. Williams, allotype female; Near Napo, Feb. 14, 1923, F. X. Williams, 1 female paratype; Río Upano, Macas, Jan. 25, 1939, F. M. Brown, 1 female (AMNH); Tena, Feb. 28, 1923, F. X. Williams, holotype male; same place, Feb. 23, 1923, F. X. Williams, 2 male paratypes; same place, Apr. 12, 1923, F. X. Williams, 1 male and 1 female paratypes.

Perú: Prov. La Mar. Sivia, Dept. Ayacucho, June 16-20, 1941, F. Woytkowski, 1 male; Santa Elena Roqueron, Padro Abad., Dept. Loreto, Aug. 8, 1946, F. Woytkowski, 1 female; Satipo, July, 1942, P. Paprzycki, 1 female; 11 km. NE. Tingo Maria, Loc. Shapajilla, Dept. Huánuco, May 9, 1939, F. Woytkowski, 1 male.

Chile: Santiago, Nov., 1949, L. E. Peña, 1 female.

Comparative notes: In general appearance, quite similar to *G. amazonensis* Melin, *G. bufo* (Herrich-Schäffer), and to some extent *G. vicinus* Champion. It is larger than the latter species, not as slender as *G. amazonensis* Melin, and does not have the lateral margin of the pronotum as straight as is the case in *G. bufo* (Herrich-Schäffer). It may be separated from all three by the shape of the genital capsule of the male. This may be *G. quadrimaculatus* (Guérin-Méneville). See the discussion under *G. vicinus* Champion.

The illustration of the genitalia of the male, the nature of the lateral margin of the pronotum and the distribution clearly show that *Gelastocoris martinezi* DeCarlo is a synonym of this species. DeCarlo obviously was not aware of the description of *G. fuscus* Martin.

Gelastocoris viridis n. sp.

(Pl. IV, fig. 13; Pl. V, fig. 23; Pl. VI, fig. 37)

Probably referring to this species:

1901. *Gelastocoris flavus* Champion, Biologia Centrali-Americana, Rhynchota Heteroptera, vol. II, p. 349.

Size. Male: Length, 6.6 to 6.8 mm.; width of pronotum, 4.1 to 4.2 mm.; width of abdomen, 4.4 to 4.5 mm. Female: Length, 6.9 to 7.8 mm.; width of pronotum, 4.0 to 4.7 mm.; width of abdomen, 4.7 to 5.2 mm.

Color: In general apperance from light brown to dark greyish-brown. Usually with the lateral portions of the pronotum lighter than the disc. Colors present are black, brown, yellow, orange, red, green and white. The blisterlike granules are green in all but one specimen. In this specimen they are white. Below, mostly dark, especially the abdomen, which is dark brown. The legs are lighter, ringed with dark brown, dorsal surface suffused with red.

Structural characteristics. Apex of head rounded; front moderately rough; ocelli extremely small, scarcely visible, one-third width of largest blisterlike granules of the hemelytra in size. Pronotum with the disc rather rough; lateral margin of pronotum subparallel for a distance equal to one and one-fourth times the ocellocular space, diverging slightly posteriorly, then extending posterolaterad to lateral angle; posterolateral margin with anterior half convex, posterior half concave; lateral angle projecting laterad beyond base of embolium; width of pronotum slightly less than width of abdomen; base of pronotum lacking short, longitudinal carinae. Hemelytra extending to or beyond the end of the abdomen; membrane is slightly reduced; basal half of lateral margin of embolium expanded, width of expansion equal to one third the ocellocular space, expansion posteriorly not angulate, rounding into margin of posterior portion of embolium. Connexivum completely covered or nearly so by the hemelytra in the males, more expanded and visible in the females. Blisterlike granules of the hemelytra and of the other parts very large, numerous, one and one-half the width of base of hind tarsus in size. Spatulate right side of seventh ventral abdominal segment of male about half covered by preceding segment; not extending to lateral margin of abdomen; left side only slightly projecting posteriorly. Female ventral abdominal segments nearly symmetrical, incision of posterior margin of last segment broad, symmetrical or slightly bent to left. Keel hood of male genitalia triangular, covering apex, fringe trans-

verse, hairs of fringe not very long; keel hook present, short, very stout, only slightly curved, not covering any portion of pan; pan wider than long, swollen into rather thick ridge around apex, basad of this is a deep transverse, crescent-shaped depression; tumescence of right clasper not adnate to basal portion of clasper; right clasper hook nearly sickle-shaped, moderately long, thin and with a very slight lateral projection at the middle; anterolateral projection of keel absent.

Location of type. Holotype male, allotype female and one male paratype, Mt. Obando Queit, Chiapas, Mexico, Apr. 15, 1940, H. M. Smith; 1 male and 3 female paratypes, El Salto Escuintla, Guatemala, 1934, F. X. Williams in the Francis Huntington Snow Entomological Collection at the University of Kansas.

Distributional data. As given above.

Comparative notes. This small species resembles *G. nebulosus* (Guérin-Méneville) somewhat in external appearance, but it may be readily separated from this species by comparing the male genitalia. *G. viridis* does not have the keel hook recurved completely back over the base of the pan and the tumescence of the right clasper is not adnate to the basal portion of the clasper. This species may be separated from the other species by the shape of the pan, size of the blisterlike granules of the hemelytra and by the shape of the lateral margin of the pronotum.

Gelastocoris angulatus (Melin)

(Pl. IV, fig. 14; Pl. V, figs. 25, 29)

1929. *Montandonius angulatus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 169, figs. 32, 33.

Also referring to this species:

1929. *Gelastocoris flavus* Martin, Univ. Kansas Sci. Bull., vol. XVIII, no. 4, p. 364, pl. 58, fig. 18, pl. 59, fig. 7.
1954. *Montandonius willineri* DeCarlo, Mision de Estudios de Patologia Regional Argentina, ano XXIV, numeros 83-84, pp. 99-100, figs. 13-16.
1954. *Montandonius mansosotoi* DeCarlo, Mision de Estudios de Patologia Regional Argentina, ano XXIV, numeros 83-84, pp. 100-101, figs. 17, 18.
1954. *Montandonius bridarolli* DeCarlo, Mision de Estudios de Patologia Regional Argentina, ano XXIV, numeros 83-84, pp. 101-102, figs. 19-20.

Size. Male: Length, 7.5 to 8.8 mm.; width of pronotum, 4.7 to 5.4 mm.; width of abdomen, 4.8 to 5.7 mm. Female: Length, 8.1 to 10.6 mm.; width of pronotum, 5.2 to 6.2 mm.; width of abdomen, 5.0 to 6.5 mm.

Color. Yellowish-brown to dark reddish-brown, usually more or less concolorous. Scutellum a little darker than rest of body, one

specimen also has disc of pronotum darker than remainder of body. In most of the specimens examined, there are small black spots along the lateral margins of the pronotum and the expanded basal portion of the embolium. The connexivum has the segments darker along the bases. The large blisterlike and peglike granules are yellowish-brown, brown, reddish-brown or black. Legs faintly or darkly ringed with brown depending upon the coloration of the specimen as a whole.

Structural characteristics. Apex of head slightly concave or straight; front very rough; ocelli small, two fifths width of largest blisterlike granules of the hemelytra in size, located on small tubercles between the eyes. Pronotum with the disc rough; lateral margin of pronotum, nearly straight, usually faintly concave; lateral angle when present very obtuse, usually this portion of the pronotum is more or less rounded; projecting laterad beyond base of embolium; base of pronotum provided with six to eight short, longitudinal carinae. Hemelytra extending to or beyond end of abdomen, in males, usually shorter than abdomen in females, one small female has the hemelytra extending well beyond the end of the abdomen; membrane varies in size, but it is rather reduced in most specimens, the small female has a very well-developed membrane; basal half of lateral margin of embolium greatly expanded, width of expansion equal to one half ocellocular space, expansion posteriorly not angulate, rounded, expansion as a whole rectangular. Connexivum, broad, extending from expansion of embolium all around hemelytra in females, quite visible in males. Large granules of hemelytra and other parts more elevated, peglike, numerous, largest granules oval, about two times as long as width of base of hind tarsus. Spatulate right side of seventh ventral abdominal segment of male elongate, extending to lateral margin of abdomen; hardly covered by preceding segment; left side greatly projecting posteriorly. Female ventral abdominal segments nearly symmetrical, the incision of the posterior margin of last segment broad, and bent slightly to the left. Keel hood of male genitalia on the right side of keel, greatly reduced, fringe with hairs extremely long and extending from left side, around apex and down right side of keel; keel hook absent; pan extremely large, rather oval in shape, as wide as shaft of keel level with right clasper hook; right clasper hook very characteristic, extremely long, shaped more or less like an S made backwards; tumescence of right clasper not adnate to base of

right clasper, devoid of black peglike spines; anterolateral projection of keel absent.

Location of type. In the British Museum, London, England.

Distributional data. This species was described by Melin from specimens from Brazil. The writer has examined specimens from the following localities:

Bolivia: Coroico, no date, purchased from Dr. Staudinger, 1 male; Santa Cruz, no date, J. Steinbach, 1 male.

Brazil: Chapada, Aug., no collector, 1 male; same place, July, no collector, 1 male; same place, May, no collector, 1 male; same place, June, no collector, 1 female (AMNH); same place, July, no collector, 1 male (AMNH); same place, Aug., no collector, 2 males and 1 female (AMNH).

Paraguay: Caravene, Jan. 12, 1925, F. Schade, 1 female; Moliuasque, Dept. Caruga, Dec., 1925, F. Schade, 1 female; Villarrica, Serro Pelado, Jan 28, 1929, F. Schade, 1 male; same place, Nov. 28, 1929, F. Schade, 1 female; Serro Pelado, Cordillero de la Villarica, Dec., 1926, F. Schade, 1 female; Villarrica, Mar., 1926, F. Schade, 1 female.

Comparative notes. Differing considerably from all other species. In shape of the lateral margin of the pronotum, rather similar to *G. bufo* (Herrich-Schäffer), but with the lateral angle rounded and not angulate as in the latter species. The 6 to 8 short, longitudinal carinae on the base of the pronotum; straight or concave margin of the apex of the head; peglike nature of the granules of the hemelytra, etc.; wide expansion of the basal half of the embolial margin; and the male genitalia make the identification of this species a simple matter.

DeCarlo, 1954, has proposed three new species in the genus *Montandonius* Melin, namely *M. willineri* DeCarlo, *M. mansosotoi* DeCarlo and *M. bridarolli* DeCarlo. All three are considered to be synonyms of *Gelastocoris angulatus* (Melin) by this writer. DeCarlo states that the genus *Montandonius* differs mainly from *Gelastocoris* by the presence of a clavus in the latter. *G. angulatus* (Melin), contrary to the statement by DeCarlo, has a clavus. It is true that some specimens do not appear to have a claval suture on the dorsal surface, however, a glance at the ventral surface show a distinct clavus and claval suture. Most specimens do show the claval suture dorsally. This writer can see no difference between the illustrations of *M. willineri* DeCarlo and *G. angulatus*

(Melin) in regard to the shape of the pronotum and the embolium. The other two DeCarlo names, based on unique females, are supposed to differ from *M. willineri* DeCarlo by differences in the granulations, scutellum more elevated with shallow furrows (*M. mansosotoi* DeCarlo), shorter hemelytra (*M. bridarolli* DeCarlo) and by the "characteristic valves of the genitalia." This writer considers these to be individual variations.

Gelastocoris apureensis Melin

1929. *Gelastocoris apureensis* Melin, Zoologiska Bidrag Fran. Uppsala, Band 12, p. 159, fig. 13.

Original description: "Front of caput somewhat rough, between ocelli a small knoblike protuberance, laterally slightly sinuated, and apically rounded; fringe usually stout, of medial length. Structure of pronotum fairly marked; side without distinctly flattened margin, level with transversal furrow, projecting to an almost right, somewhat rounded angle, anterior part of edge slightly angularly bent, in front somewhat crenulated; posterior part somewhat dentated; anterior corner fairly stout, posterior one not very prominent; posterior margin of pronotum fairly deeply sinuated before scutellum. Membrane fairly narrow (exposing a broad connexivum) with fairly big granules, terminally not very hyaline; embolium, laterally, narrowly shelved. Mesosternal process short, broad, dentated. The 6th abdominal sternite of female slightly restricted.

"Coloration, greyish-brown; legs indistinctly ringed.

"Length 6.5, breadth 4 mm.

"Museum of Paris 3 sp. (types): 1?, 2 f. S. Fernando de Apure, Venezuela (Maindron).

"This species somewhat resembles *G. amazonensis* but with the exception of a smaller size may be distinguished by the side of the pronotum lacking a distinctly flattened margin and the process being less prominent. The nature of apical incision of the 6th abdominal segment of female could not be observed on collected specimens."

The writer has not seen the type specimens and has in the collections before him only two specimens from Venezuela. These two specimens, one male and one female, seem to agree fairly closely with the original description of *G. apureensis* Melin, but the genitalia of the male shows that it is typical *G. nebulosus* (Guérin-Méneville). Since the size and the shape of the lateral angle of the pronotum are quite variable in the latter species, it is

the opinion of the writer that Melin's species will probably prove to be a synonym of *G. nebulosus* (Guérin-Méneville). For the present, however, it seems best to retain this species until the types can be examined.

Nerthrinae Kirkaldy

Gelastocorids with the rostrum appearing to arise from the ventral surface of the head, not especially stout, apical portion often projecting anteriorly. Anterior leg with the tarsus fused to the tibia, not articulate, with only one well-developed tarsal claw in adults. Ninth ventral abdominal segment of the male quite visible externally, not completely invaginated within body cavity; the posterior process only slightly modified, right clasper greatly developed and folded longitudinally to act as a guide to the simple, tubular aedeagus; in the normal position, right clasper resting in a depression of the right side of the dorsal surface of the abdomen; left clasper absent. Ventral abdominal segments of female symmetrical or asymmetrical, depending upon the species.

The Genus *Nerthra* Say

(Type of the genus, *Nerthra stygica* Say)

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1863. Stål, C., Berlin Entomologische Zeitschrift, vol. XXIV, p. 407.
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1861. Stål, C., Ofversigt af Kongl. Vetenskaps-Akademiens. Forhandlingar, Arg. 18, p. 201.
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References to this genus under *Glossoaspis* Blatchley:

1925. Blatchley, W. S., Ent. News, vol. 36, pp. 49-52.

Small to large bugs; usually of some shade of brown, nearly concolorous in most species. Front of head usually provided with tooth-like tubercles; ocelli usually present, but absent in some species; rostrum appearing to arise from the ventral surface of the head, not stout, apical portion projecting ventrally or anteriorly. Anterior leg with the tarsus fused to the tibia, not articulate, with only one well-developed tarsal claw in the adults. Ninth abdominal segment of the male quite visible externally, not completely invaginated within the body cavity; the posterior process only slightly modified; right clasper greatly developed and folded longitudinally as a guide to the simple, tubular aedeagus; in the normal position, right clasper resting in a depression of the right side of the dorsal surface of the abdomen; left clasper absent. Abdominal sternites of female either symmetrical or asymmetrical. Hemelytra usually with well-developed membrane, but membrane reduced or entirely lacking in some species; hemelytra fused together in some species, but usually separate.

At the time of the writing of this paper the species of this genus were placed in six genera, *Nerthra* Say, *Mononyx* Laporte, *Phintius* Stål, *Matinus* Stål, *Peltopterus* Guérin-Méneville and *Glossoaspis* Blatchley. The number of species in each was 1, 31, 1, 6, 3, and 1 respectively. The genus *Phintius* Stål (type of genus, *Mononyx grandicollis* Germar) was placed in the synonomy of *Mononyx* Laporte (type of genus, *Naucoris raptoria* Fabricius) by Montandon in 1899. Melin, 1929, raised this name back to generic status for a specimen of questionable origin. Most of the genera were characterized by the nature of their hemelytra. *Mononyx* Laporte had the hemelytra separate with well-developed membranes. In *Nerthra* Say (type of genus, *Nerthra stygica* Say) the membrane was lacking and the hemelytra were fused together. *Matinus* Stål (type of genus, *Mononyx alaticollis* Stål) had the membrane reduced. *Peltopterus* Guérin-Méneville (type of genus, *Naucoris rugosa* Desjardins) had the membrane lacking, hemelytra fused together, scutellum slightly reduced, and although not mentioned, the ocelli are absent. *Glossoaspis* Blatchley (type of genus, *Glossoaspis brunnea* Blatchley) was characterized in the same manner as *Peltopterus* Guérin-Méneville. A recent comparison of a specimen of *Glossoaspis brunnea* Blatchley and a type of *Peltopterus rugosus* (Desjardins) has proved that these two are identical.

Since brachypterous forms occur rather commonly in closely related families, it seems impractical to consider reduction of membrane and fusion of hemelytra as generic characters, especially when it is quite apparent that in most cases these characters have developed independently in each of the species possessing them.

Ordinarily the presence or absence of ocelli would seem to be a rather good character, but the loss of ocelli also has apparently occurred independently. This writer has found that six species lack ocelli. They all have the hemelytra entirely coriaceous and fused together, but when the structure of the head, the ventral abdominal segments of both male and female, and the male claspers are studied it can be shown that they are more closely related to other forms occurring in the areas where they are found than they are to each other.

When our knowledge of the species of this subfamily is more fully developed, it is quite possible that some of the generic names herein placed in the synonomy of *Nerthra* Say may be used at least at the subgeneric level. The writer has tentatively divided the species into eight species groups as follows:

I *Stygica* Group
- *Nerthra stygica* Say
- *Nerthra mexicana* (Melin)
- *Nerthra martini* Todd
- *Nerthra usingeri* Todd

II *Raptoria* Group
- *Nerthra raptoria* (Fabricius)
- *Nerthra buenoi* n. sp.
- *Nerthra ranina* (Herrich-Schäffer)
- *Nerthra nepaeformis* (Fabricius)
- *Nerthra terrestris* (Kevan)
- *Nerthra borealis* (Melin)
- *Nerthra tenebrosa* n. n.
- *Nerthra parvula* (Sign.)
- *Nerthra unicornis* (Melin)
- *Nerthra peruviana* (Montandon)
- *Nerthra montandoni* (Melin)
- *Nerthra quinquedentata* (Melin)
- *Nerthra americana* (Montandon)
- *Nerthra williamsi* n. sp.

III *Grandicollis* Group
- *Nerthra grandicollis* (Germar)
- *Nerthra indica* (Atkinson)
- *Nerthra lobata* (Montandon)
- *Nerthra serrata* (Montandon)
- *Nerthra asiatica* (Horvath)
- *Nerthra spissa* (Distant)

IV *Rugosa* Group
- *Nerthra rugosa* (Desjardins)
- *Nerthra macrothorax* (Montrouzier)
- *Nerthra nervosa* (Montandon)

V *Fuscipes* Group
- *Nerthra fuscipes* (Guérin-Méneville)
- *Nerthra manni* n. sp.
- *Nerthra hungerfordi* n. sp.
- *Nerthra bracchialis* n. sp.

VI *Amplicollis* Group
- *Nerthra amplicollis* (Stål)
- *Nerthra ecuadorensis* (Melin)
- *Nerthra ater* (Melin)
- *Nerthra lata* (Montandon)
- *Nerthra rudis* (Melin)
- *Nerthra corudis* n. sp.

VII *Alaticollis* Group
- *Nerthra alaticollis* (Stål)
- *Nerthra adspersa* (Stål)
- *Nerthra stali* (Montandon)
- *Nerthra elongata* (Montandon)
- *Nerthra hirsuta* n. sp.
- *Nerthra tasmaniensis* n. sp.
- *Nerthra tuberculata* (Montandon)

VIII *Laticollis* Group

Nerthra laticollis (Guérin-Méneville)
Nerthra gurneyi n. sp.
Nerthra mixta (Montandon)
Nerthra omani n. sp.
Nerthra femoralis (Montandon)
Nerthra nudata n. sp.
Nerthra ampliata (Montandon)
Nerthra macrostyla n. sp.
Nerthra robusta n. sp.
Nerthra luteovaria (Distant)
Nerthra sinuosa n. sp.
Nerthra grandis (Montandon)
Nerthra walkeri n. sp.

The writer has been unable to recognize *N. turgidula* (Distant), *N. annulipes* (Horvath), *N. planifrons* (Melin) and *N. suberosa* (Erichson). Therefore these species have not been included in the species groups given above. It is possible that *N. tuberculata* (Montandon), which is included in the *alaticollis* group, should be placed in a group to itself. *Nerthra rudis* (Melin) and *N. corudis* n. sp. are placed in the *amplicollis* group, but they seem to be intermediate between this group and the *fuscipes* group. The females of the *rugosa, laticollis* and *alaticollis* groups have the last visible abdominal sternite more or less projecting posteriorly, not emarginate as in the other species groups, and many species have spined ovipositors. The terminal (VI to IX) abdominal sternites of the males of these three groups are usually rather small, the width of the posterior margin of the sixth segment less than one half the width of the posterior margin of the fourth segment; in the males of the other species groups the posterior margin of the sixth segment is equal to or greater than one half the width of the posterior margin of the fourth abdominal sternite. The name *Peltopterus* (type of genus, *Naucoris rugosa* Desjardins) would be available in either a generic or subgeneric sense if it were decided to remove these three species groups from *Nerthra* Say or to place them in an atypical subgenus. The writer does not believe that we have sufficient knowledge at this time to take this action and therefore he has not done so.

KEY TO THE SPECIES OF NERTHRA *

1.	Hemelytron with membrane reduced or entirely coriaceous	2
	Hemelytron with membrane well developed	15
2. (1)	Ocelli present	8
	Ocelli absent	3
3. (2)	Lateral margin of hemelytron from nodal furrow to apex, bent up almost at a right angle to rest of hemelytron, *N. hirsuta* n. sp. p. 417	
	Lateral margin of hemelytron not as above	4

* Does not include *N. elongata* (Montandon), (p. 436); *N. turgidula* (Distant), (p. 406); *N. serrata* (Montandon) (p. 409); *N. annulipes* (Horvath), (p 426); *N. planifrons* (Melin), (p. 388); *N. suberosus* (Erichson), (p. 438).

4. (3) Apex and lateral margins of head provided with sharp-pointed tubercles; scutellum lacking groups of black bristles on lateral portions 5
Apex and lateral margins of head lacking sharp-pointed tubercles; scutellum with a group of bristles on lateral portions 6
5. (4) Large species, over 8 mm.; last three abdominal sternites of male small, right side of seventh abdominal sternite spatulate, partially covered by preceding sternite; clasper of male simple, sickle-shaped; bristles spiniform, *N. williamsi* n. sp. p. 383
Smaller species, under 8 mm.; last three abdominal sternites of male rather large, right side of seventh abdominal sternite entirely covered by preceding sternite; clasper of the male with a large dorsomedial process; bristles clavate ..... *N. americana* (Montandon) p. 381
6. (4) Hemelytra with large longitudinal carinae 7
Hemelytra without such carinae, nearly smooth, with a broad, rounded elevation in the middle of each hemelytron, this elevation usually covered with a group of bristles ..... *N. rugosa* (Desjardins) p. 412
7. (6) Pronotum widest at posterior angle; posterior angle of pronotum acute; tubercles on front of head very large, densely covered with short, clavate bristles, *N. macrothorax* (Montrouzier) p. 414
Pronotum widest at middle of lateral margin; posterior angle obtuse; tubercles on front of head rather small, not densely covered with bristles; longitudinal carinae of hemelytra very prominent ... *N. nervosa* (Montandon) p. 416
8. (2) Membrane limited to a very narrow strip extending along inner margin from apex of hemelytron to scutellum, *N. sinuosa* n. sp. p. 440
Membrane lacking, hemelytron entirely coriaceous 9
9. (8) Hemelytra fused together 10
Hemelytra separate, not fused together 11
10. (9) Terminal abdominal sternites of male large, width of posterior margin of sixth abdominal sternite (measured from one caudolateral angle to the other) greater than one half the width of the posterior margin of the fourth abdominal sternite (measured along posterior margin from the median notch to the lateral margin of the right side); posterior margin of last visible abdominal sternite of the female emarginate ..... *N. stygica* Say p. 354
Terminal abdominal sternites of male small, width of posterior margin of sixth abdominal sternite less than one half the width of the posterior margin of the fourth abdominal sternite; posterior margin of last visible abdominal sternite of the female not emarginate, *N. walkeri* n. sp. p. 439

11. (9) Apex and lateral margin of head with five large tooth-like tubercles; base of scutellum medially strongly depressed; hemelytra, scutellum and pronotum with groups of jet black, rather large, clavate bristles,
N. grandis (Montandon) p. 440

Apex and lateral margin of head lacking toothlike tubercles or if present, very small; base of scutellum not strongly depressed; hemelytra, scutellum and pronotum lacking groups of large, black, clavate bristles 12

12.(11) Posterior angle of pronotum angulate 13

Posterior angle of pronotum rounded, not angulate,
N. alaticollis (Stål) p. 432

13.(12) Lateral margin of head with a tubercle directly below inner margin of eye; apex of head depressed, base of depression wider than distance between ocelli,
N. adspersa (Stål) p. 434

Lateral margin of head lacking a tubercle below the inner margin of eye; apex of head depressed, base of depression less in width than distance between ocelli 14

14.(13) Connexivum very prominent from dorsal view (at least 4 segments exposed); clasper of male recurved and bluntly knobbed apically ..... *N. stâli* (Montandon) p. 435

Connexivum not as above (only two segments exposed); clasper of male apically neither recurved nor bluntly knobbed, straight, tapering to a sharp point
N. tasmaniensis n. sp. p. 437

15. (1) Basal half of embolium expanded laterally (except *N. asiatica* Horvath); ovipositor lobes of female quite distinctly projecting posteriorly beyond rest of abdomen 16

Basal half of embolium not expanded; ovipositor lobes of female usually not projecting posteriorly beyond rest of abdomen 19

16.(15) Mesosternal elevation apically greatly expanded laterally, two times as wide as width of mid-femur, apex depressed in middle, directed anteriorly as a shelf,
N. grandicollis (Germar) p. 401

Mesosternal process apically not very expanded laterally, about as wide as width of mid-femur, apex convex, not directed anteriorly as a shelf 17

17.(16) Embolium not expanded laterally; females large over 10.5 mm.; lateral edge of pronotum more or less rounded,
N. asiatica (Horvath) p. 410

Embolium expanded laterally; females medium-sized, not over 10.5 mm.; lateral edge of pronotum with several sinuosities 18

18.(17) Ovipositor of female strongly lobed and projecting posteriorly beyond rest of abdomen; expansion of embolium more or less triangular, very salient; clasper of male with right side of base of swollen apical half broadly angulate;

last visible abdominal sternite of female with lateral, submarginal tumescences ... . *N. lobata* (Montandon) p. 407

Ovipositor of female slightly projecting posteriorly beyond rest of abdomen; expansion of embolium more elongated, but not so salient; clasper of male with right side of base of swollen apical half more or less rounded; last visible abdominal sternite of female without lateral, submarginal tumescences ..... *N. indica* (Atkinson) p. 405

19.(15) Females with posterior margin of last visible abdominal sternite conspicuously emarginated; ovipositor lobes completely exposed, fitting into the emargination; males with the greatest width of posterior margin of sixth abdominal sternite (measured from one caudolateral angle to the other) subequal to or greater than one half the width of the fourth abdominal sternite (measured along the posterior margin, from the median notch to the lateral margin of the right side) [except *N. nepaeformis* (Fabricius)] 31

Females with posterior margin of last visible abdominal sternite not emarginate, usually more or less projecting posteriorly, lobes of ovipositor usually only slightly exposed or entirely covered by the last visible abdominal sternite; males with width of the posterior margin of the sixth abdominal sternite less than one half the width of the posterior margin of the fourth abdominal sternite [except *N. spissa* (Distant), in which case the widths are subequal] 20

20.(19) Front of head with rows of white tubercles which form an inverted V ..... *N. tuberculata* (Montandon) p. 431

Front of head lacking such white tubercles 21

21.(20) Apex of head without toothlike tubercles 22

Apex of head with toothlike tubercles present 23

22.(21) Head entirely lacking toothlike tubercles *N. nudata* n. sp. p. 425

Head with two small, broad, superapical, toothlike tubercles present ..... *N. spissa* (Distant) p. 412

23.(21) Anterolateral and lateral margins of pronotum concave, *N. laticollis* (Guérin-Méneville) p. 418

Not with both anterolateral and lateral margins concave 24

24.(23) Pronotum distinctly wider than greatest width of abdomen, abdomen less than 90% of width of pronotum, *N. mixta* (Montandon) p. 420

Pronotum about equal to or only slightly wider than abdomen, abdomen more than 90% of width of pronotum ... 25

25.(24) Basal portion of lateral margin of embolium convex; front femora usually suffused with red, *N. femoralis* (Montandon) p. 423

Basal portion of lateral margin of embolium more or less concave; front femora not suffused with red 26

26.(25) Small species, under 9 mm.; basal portion of lateral margin of embolium very slightly concave or straight; last visible

abdominal sternite of female with the posterior margin angularly projecting on each side of apex, which is slightly concave; clasper of male with basal portion of apical half broadly expanded, flattened dorsoventrally, small under 2.5 mm. ... *N. luteovaria* (Distant) p. 430

Larger species, over 9 mm.; basal portion of lateral margin of embolium concave; last visible abdominal sternite of female with posterior margin laterad of apex more or less rounded; clasper of male not as above, not flattened dorsoventrally, either with apical half of clasper expanded or clasper with the apical half not expanded ... 27

27.(26) Clasper of male with the greatest portion of apical half greatly expanded ... 28

Clasper of male not greatly expanded apically ... 30

*28.(27) Clasper with the dilation laterally angularly projecting, forming almost a right angle ... *N. robusta* n. sp. p. 429

Clasper with the dilation laterally not angularly projecting, more or less lobed, concavely depressed basad of of the broadest part of the dilation ... 29

29.(28) Clasper large, over 4 mm. in length; lobe on right side very prominent, constricted at base ... *N. macrostyla* n. sp. p. 428

Clasper smaller, under 3 mm. in length, indistinctly lobed, lobe not constricted at base ... *N. ampliata* (Montandon) p. 426

30.(27) Lateral margin of embolium strongly concave at basal third; clasper nearly straight, bent laterad at apex, *N. omani* n. sp. p. 422

Lateral margin or embolium not as concave at basal third; clasper more or less curved, not distinctly bent laterad at apex ... *N. gurneyi* n. sp. p. 419

31.(19) Edge of anterior dilation of front femur nearly forming a right angle with posterior side of femur ... 32

Edge of anterior dilation or front femur forming an acute angle with posterior side of femur ... 33

32.(31) Anterior basal angle of anterior dilation of front femur more or less rounded; last abdominal segment of female ventrally with a tumescence on either side of the emargination of posterior margin ... *N. raptoria* (Fabricius) p. 366

Anterior basal angle of anterior dilation of front femur pointed; last abdominal segment of female ventrally without a tumescence on either side of emargination of posterior margin ... *N. buenoi* n. sp. p. 365

33.(31) Eighth abdominal sternite of male equal to or less than length of ninth abdominal segment; ovipositor of female longer than wide ... 34

* The writer also has been unable to find key characters for females of *N. robusta* n. sp., *N. macrostyla* n. sp., *N. ampliata* (Montandon), *N. omani* n. sp., and *N. gurneyi* n. sp. For the present it is necessary to use distribution, size and association with male to identify these females. Fortunately, these are insular species and may be separated on distributional data in most cases.

Eighth abdominal sternite of male longer than (usually at least twice as long) ninth abdominal sternite; ovipositor of female small, as wide as or wider than long 57

34.(33) Prominent patches of black bristles on scutellum 35
Without such patches of black bristles on scutellum 39

35.(34) Bristles on scutellum in narrow longitudinal bands 36
Bristles not in narrow longitudinal bands, usually in rather oval patches 38

36.(35) Posterior part of abdomen strongly dilated laterally 37
Posterior part of abdomen not strongly dilated laterally, *N. unicornis* (Melin) p. 378

37.(36) Bristles of scutellum short, clavate ..*N. montandoni* (Melin) p. 380
Bristles of scutellum long, scarcely or not at all clavate, *N. peruviana* (Montandon) p. 379

38.(35) Apex of the head concavely excavated, *N. ranina* (Herrich-Schäffer) p. 368
Apex of the head rather pointedly projecting; tubercles at the apex fused basally .....*N. unicornis* (Melin) p. 378

39.(34) Apex of head pointedly projecting, terminating in one or more apical tubercles 40
Apex of head not projecting pointedly, rather concavely excavated 44

40.(39) Superapical tubercles present 51
Superapical tubercles absent 41

41.(40) Last abnominal sternite of male very large, approximately two-fifths as wide as fifth abdominal sternite; last visible abdominal sternite of female with anterior part of emargination forming an acute angle 42
Last abdominal sternite of male smaller, about one-fourth as wide as fifth abdominal sternite; last visible abdominal sternite of female with anterior part of emargination rounded 43

42.(41) Sides of pronotum at the level of the transverse furrow distinctly projecting beyond the base of embolium; sides of pronotum noticeably converging anteriorly, *N. terrestris* (Kevan) p. 373
Sides of pronotum at the level of the transverse furrow very slightly projecting beyond base of embolium; sides of pronotum more or less parallel .. *N. borealis* (Melin) p. 375

43.(41) Basal third of embolium dilated, edge rounded; body flattened; greatest width of seventh abdominal sternite of the male less than one-half the width of the posterior margin of the fourth abdominal sternite, *N. nepaeformis* (Fabricius) p. 371
Basal third of embolium narrowed, not rounded, usually slightly sinuous; body not so flattened; greatest width of seventh abdominal sternite of male about equal to one-half the width of the posterior margin of the fourth abdominal sternite .....*N. tenebrosa* n. n. p. 376

44.(39) Males 45
Females 49
45.(44) Apical half of clasper sword- or sickle-shaped, more or less simple 46
Apical half of clasper not as above 47
46.(45) Sides of pronotum rounded and projecting, *N. ranina* (Herrich-Schäffer) p. 368
Sides of pronotum straight, slightly sinuous, *N. parvula* (Signoret) p. 362
47.(45) Apical part of clasper bifurcate, processes of approximate equal size and pointed ..... *N. amplicollis* (Stål) p. 384
Not conspicuously bifurcate, but with a dorsomedial process, this process much smaller than apical portion of clasper 48
48.(47) Dorsomedial process, oval, flattened in tangential plane to longitudinal axis of clasper ..... *N. ater* (Melin) p. 389
Dorsomedial process, cylindrical or sometimes flattened in radial plane to longitudinal axis of clasper, *N. ecuadorensis* (Melin) p. 387
49.(44) Emargination of last visible abdominal sternite continuing as a long curved groove to the right, forming a distinct lobe or flap ..... *N. ranina* (Herrich-Schäffer) p. 368
Emargination not as above 50
50.(49) Anterior end of left ovipositor lobe twisted to the right and covering the anterior end of the right ovipositor lobe, *N. rudis* (Melin) p. 390
Anterior end of left ovipositor lobe not twisted to cover anterior end of right ovipositor lobe, *N. amplicollis* (Stål) p. 384 and *N. ecuadorensis* (Melin) p. 387
51.(40) Males 52
Females 54
52.(51) Apex of clasper of male very broad, flattened in an oblique dorsoventral plane ..... *N. usingeri* Todd p. 360
Apex of clasper swollen but not as broad and not flattened as above 53
53.(52) Clasper with slight processes on the lateral and dorsal surfaces ..... *N. martini* Todd p. 358
Clasper with a prominent process on the dorsomedial surface ..... *N. mexicana* (Melin) p. 356
54.(51) Last abdominal sternite of female without obvious depressions or tumescences, nearly symmetrical, *N. lata* (Montandon) p. 389
Last abdominal sternite of female with obvious depressions or tumescences or both, asymmetrical 55
55.(54) Head with two apical tubercles 56
Head with only one or without apical tubercles, *N. parvula* Signoret p. 362 and *N. quinquedentata* (Melin) p. 363
56.(55) Last abdominal sternite more or less pointedly emarginated, *N. martini* Todd p. 358
Last abdominal sternite with a rounded emargination, *N. mexicana* (Melin) p. 356 and *N. usingeri* Todd p. 360

*57.(33) Ninth abdominal sternite moderately large, about one-half as wide as eighth abdominal sternite; right side of posterior margin of fifth abdominal sternite strongly convex, *N. corudis* n. sp. p. 392

Ninth abdominal sternite small, approximately one-third as wide as eighth abdominal sternite; right side of posterior margin of fifth abdominal sternite nearly straight, slightly concave 58

58.(57) Eighth abdominal sternite of male over one-half as wide as fifth abdominal sternite ..... *N. hungerfordi* n. sp. p. 398

Eighth abdominal sternite of male about one-half as wide as fifth abdominal sternite 59

59.(58) Clasper with two projections on the medial surface, *N. fuscipes* (Guérin-Méneville) p. 393

Clasper with one projection on the medial surface 60

60.(59) Mediobasal angle of medial projection of the clasper rounded ..... *N. bracchialis* n. sp. p. 400

Mediobasal angle of medial projection of the clasper deeply sinuated ..... *N. manni* n. sp. p. 396

Nerthra stygica Say

(Pl. XII, fig. 110; Pl. XIII, fig. 117; Pl. XIV, fig. 130)

1832. *Nerthra stygica* Say, Heteropterous Hemiptera of North America, New Harmony, Indiana, p. 37.
1859. *N. stygica* Leconte, Complete Writings of Thomas Say, vol. I, p. 364.
1876. *N. stygica* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, no. 4, p. 139.
1905. *N. stygica* Torre-Bueno, Ohio Nat., vol. V, p. 288, figs. 1, 2.
1906. *N. stygica* Kirkaldy, Trans. Am. Ent. Soc., vol. XXXII, p. 149.
1910. *N. stygica* Banks, Catalogue of the Nearctic Hemiptera-Heteroptera, separate publ. of Am. Ent. Soc., p. 11.
1914. *N. stygica* Barber, Bull. Am. Mus. Nat. Hist., vol. XXXIII, p. 498.
1917. *N. stygica* Van Duzee, Catalogue of Hemiptera, Univ. California Publ., vol. I, p. 474.
1925. *N. stygica* Blatchley, Ent. News, vol. 36, pp. 49-52.

Also referring to this species:

1863. *Mononyx stygica* Stål, Berl. Ent. Zeitsch., vol. VII, p. 406.
1886. *M. stygica* Uhler, Check List of Hemiptera-Heteroptera of North America, p. 27.

Size. Male: Length, 6.1 to 6.6 mm., width of pronotum, 4.4 mm., width of abdomen, 4.4 to 4.5 mm. Female: Length, 7.3 to 7.8 mm., width of pronotum, 5.0 to 5.2 mm., width of abdomen, 5.2 to 5.4 mm.

Color. Above: yellowish-brown to dark brown or even black, usually with the anterior two thirds of each segment of the connexivum, the scutellum, the disc of the pronotum and the head, darker. Below: forelegs dark brown, others lighter, femora ringed with two

* Remaining couplets refer to males only. Females are unknown or do not appear to possess key characters. Identification of the females must therefore be based upon size, distribution and association with males.

brown bands; abdomen brown, posterolateral area of each segment yellowish-brown, median portion of abdomen with a U-shaped series of yellow or yellowish-brown spots.

Structural characteristics. Front of head projecting, apex with small, rather sharp-pointed tubercles, superapical tubercles present, broad, not sharp-pointed, a lateral toothlike tubercle present between the superapical tubercle and the eye, the lateral tubercle small, irregular in shape; ocelli present, rather small, often difficult to locate in light colored specimens. Lateral margins of pronotum nearly straight but slightly convergent anteriorly, anterior one fourth more abruptly converging; posterolateral margin rounded; posterior margin nearly straight, slightly sinuous before scutellum; pronotum widest at transverse furrow, equal to or slightly less than abdomen in width; disc elevated, lateral expansions nearly flat. Scutellum moderately large, flat, depressed at base and inclined to apex which is slightly elevated. Hemelytra entirely coriaceous, fused together, extending posteriorly as far as end of abdomen; basal half of embolium expanded laterally, nearly as wide as pronotum. Connexivum expanded, but more so in the female than the male. Bristles moderately long, usually dark brown or black, clavate, those on the hemelytra arranged to some extent in faint rows following or paralleling the sutures. Abdominal sternites of female asymmetrical; posterior margin of last visible sternite deeply and triangularly emarginate, keeled, keel anteriorly running obliquely to the right, a small submarginal tumescence on the right side, a larger tumescence to the left side, also a very prominent depression anterolaterad of the left side of the emargination. Nearly identical in the shape of the abdominal sternites to *N. martini* Todd or *N. mexicana* (Melin). Abdominal sternites of male asymmetrical; ninth sternite oval, wider than long, 32:15, fairly large, about one fourth width of abdomen, subequal in length to eighth sternite, but longer than seventh. Clasper of male very similar to that of the *N. mexicana* (Melin) and *N. martini* Todd. Apical half swollen slightly and slightly recurved. Apex narrowed, rather abruptly into short process which curves in toward the middle of the body, a projection arising from the dorsomedial surface at the base of the swollen portion of the clasper.

Location of type. Unknown. Some of Say's types are supposedly in the collection of the Philadelphia Academy of Science, Philadelphia, Pennsylvania.

Distributional data. This species is known from Florida and Georgia. The writer has studied specimens from the following localities in Florida:

Capon, Apr. 18, no collector, 1 female, (USNM); Ch. Hbr. (Charlotte Harbor?), no date, Mrs. A. T. Slosson, 1 female, (AMNH); Dunedin, March 20, 1923, W. S. Blatchley, 1 female, (Purdue Coll.); same place, Feb. 21, 1926, W. S. Blatchley, 1 female, (Purdue Coll.); Enterprise, May 13, no collector, 1 male, (USNM); Fort Myers, Nov. 15, 1911, no collector, 1 male and 1 female, (AMNH); Jacksonville, no date, Ashmead, 1 female; Pensacola, Oct. 11-14, 1914, no collector, 1 female, (AMNH).

Comparative notes. This species is quite close to *N. mexicana* (Melin) and *N. martini* Todd. It differs from these two in that the hemelytra are entirely coriaceous and fused together. If this form had normal wings it would be quite difficult to separate it from the two previously mentioned species. The pronotum is slightly different also, but this may be due to the brachypterous condition. This species can be separated from *N. americana* (Montandon) and *N. williamsi* n. sp., which also have entirely coriaceous and united hemelytra, by the presence of ocelli, shape of the abdominal sternites of the female, and by the male clasper.

Nerthra mexicana (Melin)

(Pl. VII, fig. 43; Pl. IX, figs. 69, 75; Pl. X, fig. 94)

1929. *Mononyx mexicanus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 187-188, figs. 80-83.

Size. Male: Length, 6.8 to 7.4 mm.; width of pronotum, 4.3 to 5.0 mm.; width of abdomen, 4.2 to 4.9 mm. Female: Length, 8.0 to 8.1 mm.; width of pronotum, 5.3 mm.; width of abdomen, 5.4 mm.

Color. Dark brown to black, ventral side slightly lighter than dorsal surface, last four segments of male abdomen yellowish-brown with dark brown punctations. Last abdominal segment and anal flaps of female pale yellow. Posterior edge of segments of connexivum with a thin, pale yellow area. Intermediate and hind legs with two dark rings at middle of femur and three dark rings on tibia, one basal, one apical and one medial. Front legs light brown with dilation of femur and the trochanters lighter than the rest.

Structural characteristics. Apex of head more or less pointedly projecting, apical tubercles rather slender, usually sharply pointed, appearing between superapical tubercles when viewing the specimen from above; a few small tubercles laterad of superapical

tubercles. Pronotum widest at transverse furrow, not quite as wide as abdomen in the female, slightly wider than abdomen in the male; lateral margin of pronotum more or less rounded, anterior two thirds to three fourths nearly straight, converging anteriorly, posterior fourth of lateral margin nearly straight, weakly oblique. Scutellum broad, rather large, without prominent tumescences. Hemelytra extending beyond tip of abdomen; embolium narrow, lateral margin nearly straight. Connexivum not very prominent, almost covered by the hemelytra, especially in the male. Bristles small, sparsely distributed on body on the specimens before the writer. Abdominal sternites of the male asymmetrical; ninth abdominal sternite small, oval, wider than long, slightly longer than eighth abdominal sternite; seventh abdominal sternite roundly spatulate on right side; fifth abdominal sternite very short medially. Abdominal sternites of the female asymmetrical; posterior margin of last visible abdominal sternite roundly emarginated; a moderate tumescence on the left side, a faint tumescence on the right side of the last visible abdominal sternite; a deep, elongate, transverse depression extending along the anterior margin of the last visible abdominal sternite from the median line of the abdomen to the tumescence on the left side. Clasper of male swollen apically, a rather prominent projection at the middle of the medial surface, aedeagal furrow visible on apical half of ventral surface.

Location of type. In the Museum of Stockholm, Stockholm, Sweden.

Distributional data. Melin listed four specimens in his description of this species. One is from Guatemala City, Guatemala, and is a female. The other three are labeled "Mexico," "Salle" and comprise the type series. The writer has examined the type and also a series of six specimens, three males and three females, from Tejupilco, Dist. of Temascaltepec, Mexico, June-July, 1933, H. E. Hinton.

Comparative notes. Closely related to *N. martini* Todd but differing in the shape of the clasper of the male and having the emargination of the posterior margin of the last visible abdominal sternite of the female more rounded anteriorly than is the case in *N. martini* Todd, and also differing in that the pronotum in this species is usually wider than or subequal to the width of the abdomen, while in *N. martini* Todd the pronotum is not as wide as the abdomen.

Nerthra martini Todd

(Pl. VII, fig. 42; Pl. IX, fig. 70; Pl. X, fig. 91)

1954. *Nerthra martini* Todd, Pan-Pacific Entomologist, XXX, No. 2, pp. 113-116, figs. 1 and 5.

Referring to this species:

1876. *Mononyx badius* Uhler, Bull. U. S. Geol. Surv., pp. 336-337.

1894. *Mononyx stygicus* Uhler, Proc. California Acad. Sci., ser. 2, vol. IV, pp. 290-291.

Size. Male: Length, 7.0 to 7.6 mm.; width of pronotum, 4.5 to 4.8 mm.; width of abdomen, 4.5 to 5.0 mm. Female: Length, 7.8 to 8.8 mm.; width of pronotum, 4.8 to 5.3 mm.; width of abdomen, 5.0 to 5.8 mm.

Color. Varying from a yellowish-brown to black, generally a brown or reddish-brown. A whitish spot on each hemelytron mesad of the junction of the embolial and nodal sutures. In the black specimens the posterior third of the pronotum is generally spotted with pale yellow or white. Ventrally slightly lighter than dorsally; front femur uniform brown, intermediate legs light brown ringed with dark brown areas which may be faint in some specimens; last three abdominal segments lighter than rest of abdomen; connexivum with posterior third of each segment yellowish, anterior two thirds dark. A few specimens examined were uniformly reddish-brown above and with a lighter marginal band ventrally which extended the entire length of the abdomen.

Structural characteristics. Apex of the head pointedly projecting with a pair of rather sharp pointed tubercles at the tip, sometimes these tubercles are rather rudimentary; superapical tubercles present. Pronotum not very dilated laterally; lateral edge nearly straight, occasionally weakly sinuous at middle; lateral edge conspicuously converging anteriorly; posterior margin sinuated before scutellum. Pronotum at greatest width not as wide as abdomen in either sex. Scutellum broad, rather large with slight tumescence on either side, mesad of which are two faint rounded depressions. Body sparsely covered with very small bristles, those on the scutellum being slightly clavate. Hemelytra well developed extending beyond the apex of the abdomen. Lateral margin of embolium nearly straight, not dilated. Connexivum barely visible from a dorsal view in the male, quite prominent in the female because the posterior abdominal segments are greatly dilated laterally. Ninth abdominal sternite of the male rather large, over half as wide as eighth abdominal sternite, slightly longer than seventh or eighth abdominal

sternites, asymmetrical. Abdominal sternites of female asymmetrical; posterior margin of last visible abdominal sternite more or less pointedly notched; a moderate tumescence on the left side, a faint tumescence on the right side of the last visible abdominal sternite; a deep, elongate, transverse depression extending along the anterior margin of the last visible abdominal sternite from the median line of the abdomen to the tumescence on the left side. Clasper of male swollen apically; a weak process on the lateral surface and another on the dorsal surface; aedeagal furrow visible on the apical half of the ventral surface.

Location of type. Holotype male, allotype female, and 24 male and 2 female paratypes, Los Pensaguitos Cr., San Diego Co., California, Apr. 8, 1930, C. H. Martin, in the Francis Huntington Snow Entomological Collection at the University of Kansas. One male and one female paratypes, San Felipe Cr., California, Apr. 14, 1935, C. E. Norland, (Usinger Coll.). One male and one female paratypes, Los Angeles Co., California, no date, Coquillet, (USNM). One male and one female paratypes, Riverside, California, March 2, 1927, T. Craig, (CAS).

Distributional data. In addition to the type series, the writer has seen specimens from the following localities:

California. Afton Canyon, San Bernardino Co., July 17, 1931, R. E. Blackwelder, 1 male, (CAS); Ardeou, Dec. 25, 1915, J. O. Martin, 1 female, (CAS); Los Angeles, no date, P. R. Uhler, 1 male, (USNM); Palm Canyon, Apr. 15, 1916, J. O. Martin, 1 male, (CAS); Palm Springs, Riverside Co., Apr. 3, 1925, E. C. Van Dyke, 1 male, (CAS); same place, Jan. 3, 1929, Van Dyke, 1 female; same place, Aug. 2, Hubbard, 1 female, (USNM); Panamint Vy., Apr. 1891, C. V. Riley, 2 females, (USNM); Pico, Mar. 7, 1916, J. O. Martin, 1 male and 1 female, (CAS); Pine Valley, July 27, 1938, R. I. Sailer, 1 female; Santa Ana Canyon, July 12, 1931, C. H. Martin, 7 males and 3 females; Sierra Madre, June 7, 1930, C. H. Hicks, 2 males, (J. C. Lutz Coll.); Sierra Nevada Mts., no date, P. R. Uhler, 1 male, (USNM).

Baja California: Big Cyn., Sierra Laguna, Oct. 13, 1941, Ross and Bohart, 2 males and 2 females, (CAS); Cataviña, June 19, 1938, Michelbacher and Ross, 1 male, (CAS); Las Animas, Sierra Laguna, Oct. 12, 1941, Ross and Bohart, 1 male and 2 females, (CAS); Las Parras, Oct., 1925, W. M. Mann, 1 male, (USNM); Loreto, Feb., 1923, W. M. Mann, 2 males and 3 females, (USNM); 19 mi. E. Rosario, June 17, 1938, Michelbacher and Ross, 3 males,

(CAS); "L. Cal.," no date, P. R. Uhler, 1 male, (USNM).

Arizona: "Ariz.," no date, P. R. Uhler, 1 male (USNM); "Ariz.," no date, C. F. Baker, 1 male and 1 female, (USNM).

Georgia: "Dayton," July 9, 1926, J. R. Delaney, 2 females, (PAS), J. C. Lutz Coll.*

Comparative notes. This species is very closely related to *N. mexicana* Melin and to *N. stygica* Say. It is separated from the former species by the narrow pronotum, slightly larger size, the notch of the posterior margin of the last visible abdominal sternite of the female being rather pointed at the anterior end and by the shape of the clasper of the male. It differs from *N. stygica* Say in that it has separate hemelytra with well-developed membranes, the emargination of the last visible abdominal sternite of the female slightly more pointed, and in the shape of the male genitalia. It is interesting to note that most specimens of *N. stygica* Say have been taken during the winter or early spring. If the specimens collected by J. R. Delaney are from Georgia, then there is a possibility that *Nerthra stygica* Say is a winter form of this species. During the summer of 1948, the writer attempted to locate this species in the Gulf States, but he was not successful. Perhaps future collecting and the development of our knowledge of the biology of these species will reveal the true relationships of *N. stygica* Say, *N. mexicana* (Melin) and *N. martini* Todd.

Nerthra usingeri Todd

(Pl. XV, fig. 141)

1954. *Nerthra usingeri* Todd, Pan-Pacific Entomologist, XXX, No. 2, pp. 116-117, fig. 2.

Size. Male: Length, 6.4 to 6.8 mm.; width of pronotum, 4.5 mm.; width of abdomen, 4.4 to 4.5 mm. Female: Length, 7.1 to 7.7 mm.; width of pronotum, 4.8 to 5.0 mm.; width of abdomen, 4.7 to 5.0 mm.

Color. General over-all color yellowish-brown to dark brown nearly black. Some specimens have the dorsal surface mottled with black and yellowish-brown. Ventrally slightly lighter in color than on the dorsal surface; front femora brown, darkest basally, intermediate and hind legs yellowish-brown with dark brown rings. Abdominal segments both above and below have light yellowish spots at the latero-caudal angles of each segment.

* In the original description erroneously credited to the collection of the Philadelphia Academy of Sciences.

Structural characteristics. Apex of head pointedly projecting, usually with a pair of sharp-pointed tubercles at the tip, some specimens have three and some only one apical tubercle, all are variable in size. Pronotum with the lateral margins more or less rounded, converging anteriorly and posteriorly; widest level with the transverse furrow; posterior margin deeply sinuated at the middle before the scutellum. Scutellum large, not strongly elevated. Hemelytra with well-developed membranes, extending to or beyond the end of the abdomen; lateral margins of the embolia nearly straight for the basal half then gently curving medially. Connexivum visible in both sexes, but not prominent; width of abdomen equal to or subequal to the width of pronotum. Bristles very small, short, peg-like, sparsely distributed over the body. Abdominal sternites of the male asymmetrical; ninth sternite small, oval wider than long, slightly longer than eighth sternite; seventh abdominal sternite spatulate on right side. Abdominal sternites of female asymmetrical; posterior margin of last visible abdominal sternite roundly emarginated; a moderate tumescence on the left side, a faint tumescence on the right side of the last visible abdominal sternite; a deep, elongate, transverse depression extending along the anterior margin of the last visible abdominal sternite from the median line of the abdomen to the tumescence on the left side. Clasper of male very distinctive, broad and flattened apically, widest near apex; aedeagal furrow visible on apical half of ventral surface, terminating before reaching apex; clasper flattened in an oblique dorsoventral plane.

Location of type. Holotype male, Nr. Parker Dam, California, Apr. 12, 1952, R. L. Usinger and allotype female, Wash 3.5 mi. N. Cross Roads, California, April 12, 1952, J. D. Lattin, in the collection of the California Academy of Science at San Francisco. One male and five female paratypes, Wash 3.5 mi. N. Cross Roads, California, April 12, 1952, J. D. Lattin, in the R. L. Usinger Collection at the University of California. One male and one female paratypes, same data, in the personal collection of Mr. Lattin.

Distribution. Known at this time only from the type locality. The difference in the locality of the holotype and the remainder of the specimens examined is merely a difference in labelling the specimens on the part of the two collectors. These data represent the same locality.

Comparative notes. Closely related to *Nerthra stygica* Say, *N. mexicana* (Melin) and *N. martini* Todd. This species may be sep-

arated from *N. stygica* Say by the fact that the hemelytra are normal with well-developed membranes. The distinctive clasper of the male will separate this species from the males of *N. mexicana* (Melin) and *N. martini* Todd. The females of this species differ from the females of *N. martini* Todd in that the emargination of the last visible abdominal sternite is broadly rounded basally. To the knowledge of the writer the females of this species may be separated from females of *N. mexicana* (Melin) only by distribution.

Nerthra parvula (Signoret)

(Pl. VII, fig. 44; Pl. VIII, fig. 67)

1864. *Mononyx parvulus* Signoret, Annales de la Société des Entomologique de France, XXXIII, p. 588.
1873. *M. parvulus* Walker, Catalogue of Hemiptera in British Museum, Part VIII, p. 172.
1899. *M. parvulus* Montandon, Bulletin de la Societe des Société des Sciences de Bucarest-Roumanie, An. VIII, Nos. 4 & 5, p. 402.
1909. *M. parvulus* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, Vol. X, p. 182.
1929. *M. parvulus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 188-189, figs. 88-90, 110.
1935. *M. parvulus* De Carlo, Revista Chilena de Historia Natural, Año XXXIX, pp. 106-107.

Size. Male: Length, 5.8 to 6.1 mm.; width of pronotum, 3.7 to 3.8 mm.; width of abdomen 3.6 to 3.9 mm. Female: Length, 7.0 to 7.5 mm.; width of pronotum, 4.3 to 4.9 mm.; width of abdomen, 5.0 to 5.4 mm.

Color. Yellowish-brown, scutellum darker; a dark brown spot at distal end of embolial suture; a small, median, blackish spot on the posterior margin of the head; segments of the connexivum entirely dark brown or darker on the basal portion; front legs brown; intermediate legs, hind legs and abdomen pale yellowish-brown, ringed and spotted with brown respectively.

Structural characteristics. Apex of the head weakly pointedly projecting, terminating in a small blunt knob; small indistinct superapical tubercles present (larger in females); lateral tubercles small, indistinct (more prominent in females). Pronotum widest at at level with the transverse furrow, barely projecting beyond base of embolium, about equal to abdomen in width in males, distinctly less in width than abdomen in females; lateral margins nearly straight for anterior three-fourths, slightly sinuated at middle; posterior margin sinuated before scutellum. Scutellum rather large, with a moderate tumescence on either side and a weak median longitudinal carination. Hemelytra extending to or beyond the end of the abdomen; membrane well developed; embolium elongate, lat-

eral margin straight or weakly convex. Connexivum nearly covered by the hemlytra in males, very prominent in females. Abdominal sternites of female similar to those of *N. quinquedentata* (Melin) except, there are no lateral tumescences on the last visible abdominal sternite and the depressions of that sternite are generally broader and not so deep as in the aforementioned species. Abdominal sternites of the male asymmetrical; ninth abdominal sternite oval, wider than long, about equal in length to eighth sternite. Clasper of the male simple, sickle-shaped, rather slender, aedeagal furrow visible on the apical half of the medioventral surface.

Location of type. In the British Museum at London, England.

Distributional data. This species is known only from Chile. The writer has seen specimens from the following localities in Chile: Las Brisas, Aug. 12-14, 1951, Luis Peña, 4 males and 1 female; Toulemo, Nov. 15-27, 1951, Luis Peña, 1 male and 1 nymph; El Canelo, Dec. 1950, Luis Peña, 1 male and 1 female; Guayacan, Jan. 25, 1951, Luis Peña, 1 female; El Manzano, Nov. 1951, Luis Peña, 2 females; "Sonora," no date, P. R. Uhler, 1 male, (USNM); "Chile," no date, Porter, 1 male, (USNM).

Comparative notes. This small species may be separated from *N. ranina* (Herrich-Schäffer) by the shape of the head, the pronotum not so produced laterally and by the shape of the clasper of the male and by the shape and depressions of the abdominal sternites of the female. This species is apparently very closely related to *Nerthra quinquedentata* (Melin) and the latter may only be a larger form, but there appear to be differences in the females available to this worker and it would seem best to consider them as distinct species for the present.

Nerthra quinquedentata (Melin)

(Pl. X, fig. 84)

1929. *Mononyx quinquedentatus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 188, figs. 84-87.

Size. Female: Length, 7.5 to 8.2 mm.; width of pronotum, 4.9 to 5.4 mm.; width of abdomen, 5.0 to 5.8 mm.

Color. Light yellowish brown to black, scutellum and median part of pronotum darker; a small dark brown spot at the distal end of the embolial suture; anterior part of segments of the connexivum, brown or black, posterior part pale yellow; front legs light brown, intermediate and hind legs pale yellow ringed with brown; abdominal segments dark brown with yellowish-brown punctations.

Structural characteristics. Apex of head pointedly projecting, terminating in one apical tubercle; a pair of superapical tubercles present; one lateral tubercle present on either side of the head, as large as the superapical tubercles. Pronotum widest at a level with the transverse furrow, not as wide as the abdomen; lateral margin with the anterior three fourths nearly straight to weakly rounded, distinctly converging anteriorly; posterior margin sinuated before scutellum. Scutellum fairly large with moderate lateral tumescences and a weak longitudinal carination; a slight depression between the lateral tumescence and carination; tumescences and carination covered rather thickly with brown bristles which are slightly clavate. Hemelytra extending beyond the end of the abdomen. Connexivum moderately prominent. Abdominal sternites of the female asymmetrical; last visible abdominal sternite with the posterior margin medially deeply emarginated, anterior end of emargination twisted slightly to the right; a tumescence near the lateral margin on each side, the one on the left side much larger than that on the right side; three depressions on the last sternite, one on either side of the emargination and one medial depression, the lateral depression on the left side large and extending from a point slightly to the left of the median line along the anterior margin of the last visible sternite to the base of the large tumescence on the left side.

Location of type. In the Museum of Copenhagen, Copenhagen, Denmark.

Distributional data. Melin studied two specimens from Argentina. This worker has examined specimens from the following localities:

Argentina: "Argentina," no date, Wehseregt, 1 female, (Mus. Prague); Mendoza, no date, G. S. Reed, 1 female.

Brazil: Nova Teutonia, Dec., 1946, Fritz Plaumann, 1 female.

Chile: "Chile," Dec., 1923, no collector, 4 females.

Comparative notes. This species is easily identified by the presence of five tubercles on the front of the head and by the shape of the abdominal sternites of the female. It is very closely related to *N. parvula* (Signoret), but the last visible abdominal sternite has lateral tumescences which are lacking in the latter species and the depressions are narrower and deeper. In many ways this species shows affinities to the *stygica* group even though its range is remote from those species.

The four females from Chile are not typical. The toothlike tubercles of the head are almost completely obsolete and the abdominal sternites vary slightly from those of the typical female in that the apex of the emargination of the last visible sternite is not bent to the right and in that the tumescence on the left side of the last visible sternite is a little larger than in the typical female.

Nerthra buenoi n. sp.

(Pl. III, fig. 10; Pl. X, fig. 82)

Size. Female: Length, 4.2 mm.; width of pronotum, 2.6 mm.; width of abdomen, 2.7 mm.

Color. Uniformly brown above, except the posterior half of each segment of the connexivum and the tip of the membrane of the hemelytra which are pale yellowish-brown. Light yellowish-brown ventrally with brown punctations on the abdominal segments, tarsal claw of foreleg dark brown, intermediate and hind legs with the femora ringed medially by two faint, slightly darker areas.

Structural characteristics. Front of head with apex concavely excavated, a stout tubercle on either edge of the excavation; lateral tubercles small forming into a group between the eye and the excavation of the apex. Lateral margin of the pronotum with the anterior two thirds faintly rounded, posterior third straight, obliquely converging to base of embolium; posterior margin sinuated before scutellum. Pronotum widest at transverse furrow, not quite as wide as abdomen. Scutellum fairly large with weak tumescences on either side. Hemelytra extending beyond tip of abdomen; embolium narrow, elongate, lateral margin weakly curved. Body covered sparsely with short clavate bristles. Anterior margin of front femur forming approximately a right angle with posterior margin of femur; anterior dilation projecting into a rather sharp point at the anterior basal angle. Abdominal sternites of the female nearly symmetrical; emargination of the posterior margin of the last visible abdominal sternite rounded; lateral areas on either side of emargination flattened, without a trace of tumescences.

Location of type. Holotype, female, from Bnito Prov., Pernambuco, Brazil, Feb., '83, no collector, in the Francis Huntington Snow Entomological Museum at the University of Kansas.

Distributional data. As given for the type.

Comparative notes. This species though very closely related to *N. raptoria* (Fabricius) seems sufficiently different to constitute

another species. It differs from the preceding species by the more pointedly projecting anterior dilation of the front femur, by the absence of tumescences on the last visible abdominal sternite and by its smaller size.

Nerthra raptoria (Fabricius)

(Pl. III, fig. 7; Pl. VII, fig. 46; Pl. VIII, fig. 64; Pl. X, fig. 88)

1803. *Naucoris raptoria* Fabricius, Systema Eleutheratorum, vol. 3, Systema Rhyngotarum, p. 111.
1833. *Mononyx raptoria* Laporte, Essai d'une Classification Systématique de L'order des Hémiptères, p. 16.
1835. *M. raptoria* Brullé, Histoire Naturelle des Insectes, vol. IX, p. 275.
1840. *M. raptoria* Spinola, Essai sur les Insectes Hémiptères, Rhyngotes ou Hétéroptères, p. 63.
1840. *M. raptoria* Blanchard, Histoire Naturelle des Animaux Articules, vol. 3, p. 93.
1843. *M. raptorius* Guérin-Méneville, Revue Zoologique Travaux Inedits, p. 114.
1859. *M. raptorius* Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischen Verein zu Stettin, p. 53.
1863. *M. raptorius* Stål, Berliner Entomologische Zeitschrift, Bd. VII, p. 405.
1865. *M. raptorius* Mayr, Zoologischer Theil, Band II, Abt. 1, p. 181.
1868. *M. raptorius* Stål, Hemiptera Fabriciana, I, p. 134.
1876. *M. raptorius* Stål, Kongl. Svenska Vetenskaps-Akademiens. Handlingar, Band 14, no. 4, p. 139.
1879. *M. raptorius* Berg. Hemiptera Argentina, p. 186.
1886. *M. raptorius* Uhler, Bull. Brooklyn Ent. Soc., p. 27.
1895. *M. raptorius* Montandon, Bollettino dei Musei di Zoologia ed Anatomia comparata della R. Università di Torino, no. 219, vol. X, p. 8.
1899. *M. raptorius* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, nos. 4 et 5, p. 402.
1901. *M. raptorius* Champion, Biologia Centrali-Americana, Rhynchota Heteroptera, vol. II, p. 352, pl. 20, figs. 27, 27a.
1906. *M. raptorius* Distant, Fauna British India, vol. III, p. 14.
1906. *M. raptorius* Kirkaldy, Trans. Am. Ent. Soc., XXXII, p. 149.
1909. *M. raptorius* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 182.
1929. *M. raptorius* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 191-192, figs. 96-99, 105, 111.

Also referring to this species:

1858. *M. fusco-conspersus* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, 2, p. 82.
1863. *M. fusco-conspersus* Stål, Berliner Entomologische Zeitschrift, VII, p. 406.
1873. *M. fusco-conspersus* Walker, Catalogue of Hemiptera in the British Museum, pt. VIII, p. 172.

Size. Males: Length, 5.0 to 5.5 mm.; width of pronotum, 3.1 to 3.4 mm.; width of abdomen, 3.0 to 3.35 mm. *Female:* Length, 5.4 to 5.5 mm.; width of pronotum, 3.55 to 3.6 mm.; width of abdomen, 3.55 to 3.6 mm.

Color. Light to dark brown above; scutellum darkest, occasionally black. Anterior dilation of front femora, intermediate and hind legs pale yellowish. Tibiae and tarsi of intermediate and hind

legs with two indistinct dark rings. Venter of abdomen, brown with darker punctations. Margin of abdominal segments with the anterior half dark brown, the posterior half pale yellow.

Structural characteristics. Apex of head concavely excavated with a stout tubercle on either side of the excavation; lateral tubercles irregular, small, grouped together to form a small raised knob between eye and apex of head; ocelli rather large. Margins of pronotum more or less rounded, occasionally with sides straighter, forming two obtuse lateral angles; slightly wider than abdomen in the males, about the same width as abdomen in the females; posterior margin with area before scutellum deeply sinuous. Scutellum with lateral tumescences prominent; a weak, median longitudinal carination present; tumescences and carina covered very sparsely with slightly clavate bristles. Hemelytra extending beyond tip of abdomen; a rather large spot which is dark and smooth at the medial angle of embolium; two groups of bristles mesad and one group of bristles caudad of this spot; bristles present along embolial suture, external edge of embolium and edge of corium; embolium narrow, elongate and slightly convex at external edge. Anterior edge of front femur greatly dilated, forming an almost right angle with the posterior edge. Abdominal sternites of the male asymmetrical; ninth sternite slightly longer than eighth sternite, wider than long. Abdominal sternites of the female nearly symmetrical; last visible abdominal sternite deeply emarginated; ovipositor lobes nearly as long as last segment of abdomen; a rather small tumescence on either side of emargination near the lateral margins, the one on the left side being slightly the larger. Clasper of the male small, sickle-shaped, apex faintly hooked, aedeagal furrow visible on the distal half.

Location of type. The type specimen, a male, is located in the Museum of Copenhagen, Copenhagen, Denmark.

Distributional data. The literature lists this species from Mexico through Central and South America to Argentina. This writer has examined specimens from the following localities:

Panamá: Paraíso, C. Z., Jan. 16, 1911, E. A. Schwarz, 1 female, (USNM); "Pan.," no date, P. R. Uhler, 1 female, (USNM).

Brazil: Santárem, no date or collector, 1 male, compared with type by Doctor H. B. Hungerford in 1928; Rio Caiari-Uaupés, Amazonas, Sept. 1906, H. Schmidt, 1 male, (AMNH); West border of Matto Grosso, May, 1931, R. C. Shannon, 1 female, (USNM).

Comparative notes: This species in the past was easily separated from all others by the shape of the anterior dilation of the front femur. It can be separated from *N. buenoi* n. sp. by its larger size, the presence of tumescences on the last visible abdominal sternite of the female and by the rounded anterior basal angle of the anterior dilation of the front femur.

Nerthra ranina (Herrich-Schäffer)

(Pl. II, figs. 3, 4; Pl. III, figs. 6, 9; Pl. IV, fig. 12; Pl. VII, fig. 41; Pl. X, fig. 81)

1853. *Mononyx raninus* Herrich-Schäffer, Die Wanzenartigen Insecten, vol. IX, p. 28, fig. 896.
1859. *M. raninus* Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischen Verein zu Stettin, p. 53.
1863. *M. raninus* Stål, Berliner Entomologische Zeitschrift, vol. VII, p. 406.
1899. *M. raninus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, nos. 4 and 5, p. 401.
1909. *M. raninus* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 182.
1929. *M. raninus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 189-191, figs. 91-94.

Also referring to this species:

1929. *Mononyx niger* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 182-184, figs. 63, 64.

Size. Male: Length, 6.2 to 7.0 mm.; width of pronotum, 4.2 to 4.9 mm.; width of abdomen, 4.0 to 4.9 mm. Female: Length, 5.8 to 8.5 mm.; width of pronotum, 3.8 to 6.0 mm.; width of abdomen, 3.8 to 6.0 mm.

Color. As with size this species is very variable in coloration. The color ranges from pale yellow or light grey to black. The writer has examined some specimens showing a combination of pale yellow with a dorsal median stripe of black.

Structural characteristics. Apex of head concavely excavated, with a broad tubercle on either side of excavation; lateral tubercles rudimentary, generally forming an indistinct toothlike protuberance before the lateral depression of the head, but occasionally separate and conspicuous. Pronotum with greatest width at transverse furrow, lateral margins usually rounded; posterior margin sinuated before the scutellum. Scutellum fairly large with a tumescence frequently covered with bristles, especially in small specimens from the southern part of its range. Hemelytra extending beyond end of abdomen. Bristles sparsely scattered over body, worn off in most specimens, slightly clavate in larger specimens, distinctly clavate in small specimens. Connexivum prominent, especially in the female; posterior half of each segment light, anterior half dark.

Abdominal sternites of both male and female asymmetrical. Ninth abdominal sternite of male small, approximately equal in length to eighth abdominal sternite. Seventh abdominal sternite at its greatest length as long as eighth abdominal sternite or occasionally longer. Abdominal sternites of female very characteristic. Notch of posterior margin of last visible abdominal sternite continued as a long, narrow curved groove to the right, forming a lobe on that side; an elongate depression continuing from the groove posteriorly and a circular depression at the median part of the anterior margin. A large tumescence on the left side extending along the margin of the last two abdominal sternites, occasionally a very small tumescence on the right side of the last visible abdominal sternite near the lateral margin. The clasper of the male small and sickle-shaped, twisted, aedeagal furrow visible on apical half viewing the specimen ventrally.

Location of type. Unknown. Other Hemipterous insects of the collection of Herrich-Schäffer are located in the Museum of Munchen, Munchen, Germany.

Distributional data. The literature lists this species from Argentina, Brazil and Paraguay. The writer has studied specimens from the following localities:

Peru: Callango, no date, G. W. Kirkaldy, 5 males and 1 female; same place, no date, Haglund, 1 female, (Mus. Stockholm), type of *Mononyx niger* Melin; Guayabamba, Andes, Dept. Amazonas, Aug. 14-19, 1936, F. Woytkowski, 1 male; Huánuco, Andes, Dept. Huánuco, Sept. 6, 1937, F. Woytkowski, 18 males and 16 females; Marcapata, no date or collector, 1 male and 9 females; Pacasmayo, May 19-20, 1936, F. Woytkowski, 1 male; Puerto Bermúdez, Río Pichis, July 13-19, 1920, no collector, 1 male; Recardo Palma, 44 kil. E. Lima, Nov. 27-29, 1934, F. Woytkowski, 1 female; Río Perené and Chanchamayo, Dept. Junín, May, 1934, F. Woytkowski, 2 males and 4 females; San Beni, Dept. Junín, Sept. 5, 1935, F. Woytkowski, 2 males and 2 females; San Ildefonso, Rio Utcubamba, Dept. Amazonas, July 29, 1936, F. Woytkowski, 1 male and 1 female; San Miguel, Prov. La. Mar., Dept. Ayacucho, July 9-12, 1941, F. Woytkowski, 12 males and 8 females; San Pedro, May 15-29, 1935, F. Woytkowski, 1 male; Santa Clara, River Rímac, Sept. 22-25, 1934, F. Woytkowski, 7 males and 4 females; Tinccochaca, Aug., 1911, no collector, 1 female; Yanamonte, Prov. La. Mar., Dept. Ayacucho, Sept. 28-30, 1941, F. Woytkowski, 2 males and 1 female.

Chile: Santiago,* Aug. 26, 1949, L. E. Peña, 1 female.

Bolivia: Coroico, no date, purchased from Dr. O. Staudinger, 1 female; Espia, 1921-22, W. M. Mann, 1 male and 1 female, (USNM); Mojos, no date, N. Holingren, 2 males, (Mus. Stockholm); San Fernando Rapids, 1921-22, W. M. Mann, 1 female, (USNM); Sta. Helene, 1921, W. M. Mann, 1 female, (USNM).

Paraguay: "Albovena Srojo guasi," Nov. 16, 1926, F. Schade, 3 females; Alboveno, May 1, 1925, F. Schade, 1 female; Asunción, July, no collector, 3 females, (Car. Mus.); same place, Nov., no collector, 1 female, (Car. Mus.); Horgueta, Aug. 11, 1933, A. Schultze, 1 male and 1 female, (Usinger Coll.); same place, 45 mi. E., July 6, 1933, A. Schulze, 1 female, (J. C. Lutz Coll.); same place, Aug. 7, 1933, A. Schulze, 1 male and 1 female, (J. C. Lutz Coll.); same place, Aug. 10, 1933, A. Schulze, 3 females (J. C. Lutz Coll.); Villarrica, Jan. 6, 1923, F. Schade, 1 female; same place, May 9, 1923, F. Schade, 1 female, Villarica Serro Pelado, Nov. 28, 1929, F. Schade, 1 female.

Argentina: Catamarca, Jan. 24, 1924, Weiser, 1 female; same place, Corral Quemado, Mar., 1924, Weiser, 1 male and 1 female; same place, Apr. 1924, Walters, 1 female; same place, Fuerte Quemado, Feb. 1924, F. Walters, 1 male and 1 female; same place, Valle de Santa Maria, no date, F. Walters, 1 male; Chafiñán, Valde 9, Jan., 1922, Weiser, 1 male; Potrerillos, Mar. 16-19, 1920, no collector, 1 female; "Argentina," no date, Jensen-Haarup, 1 female; "Argentina," no date, Weiser, 1 male, (Mus. Prague).

Brazil: Nova Teutonia, Jan. 8, 1949, F. Plaumann, 4 males and 16 females; same place, Jan., 1948, F. Plaumann, 5 males and 4 females; same place, Apr. 1948, F. Plaumann, 4 males and 7 females; Nova Teutonia, Santa Catharina, Apr. 27, 1948, F. Plaumann, 5 males and 3 females; same place, Mar. 5, 1948, F. Plaumann, 1 female; Nova Teutonia, Tupan L. 2, May, 1947, F. Plaumann, 12 males and 5 females; Pará, July, no collector, 1 female, (Car. Mus.); São Paulo, no date, Mraz., 1 male, (Mus. Prague).

Comparative notes. This species can be easily separated from the other species of the genus by the shape of the male clasper and by the characteristics of the abdominal sternites of the female. The writer, after examining the type of *Mononyx niger* Melin, is of the opinion that the latter species is a synonym of *Nerthra ranina* (Herrich-Schäffer). There is considerable variation within

* This locality may be incorrect, however, the specimen is from Chile and extends the range of this species to that country.

this species as to color and size. The specimens from Perú and Bolívia are on the whole darker and somewhat larger than those from Brazil, Paraguay and Argentina. The abdominal sternites of the female and the male clasper as well as the other structures of the body are identical.

Nerthra nepaeformis (Fabricius)

(Pl. VII, fig. 49; Pl. IX, figs. 72, 74; Pl. X, fig. 93)

1775. *Naucoris nepaeformis* Fabricius, Systema Entomologiae, 2, p. 693.
1803. *N. nepaeformis* Fabricius, Systema Eleutheratorum, vol. 3, Systema Rhyngotarum, p. 111.
1868. *Mononyx nepaeformis* Stål, Hemiptera Fabriciana, I, p. 134.
1873. *M. nepaeformis* Walker, Catalogue of Hemiptera in the British Museum, pt. VIII, p. 171.
1876. *M. nepaeformis* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, vol. V, p. 138.
1879. *M. nepaeformis* Berg, Hemiptera Argentina, pp. 185-186.
1895. *M. nepaeformis* Pittier and Biolley, Instituto Fisico Geografico Nacional (Costa Rica), p. 23.
1895. *M. nepaeformis* Montandon, Bollettino dei Musei di Zoologia ed Anatomia comparata della R. Università di Torino, no. 219, vol. X, p. 8.
1899. *M. nepaeformis* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, nos. 4 et 5, p. 401.
1901. *M. nepaeformis* Van Duzee, Trans. Am. Ent. Soc., vol. XXXVII, p. 352.
1901. *M. nepaeformis* Champion, Biologia Centrali-Americana, Rhynchota Heteroptera, vol. II, p. 351.
1906. *M. nepaeformis* Torre-Bueno, Ent. News, vol. 17, p. 54.
1909. *M. nepaeformis* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. 10, p. 182.
1925. *M. nepaeformis* Blatchley, Ent. News, vol. 36, p. 52.
1929. *M. nepaeformis* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 174-177, figs. 36-38, 103, 107.
1935. *M. nepaeformis* Carlo, Revista Chilena de Historia Natural, ano XXXIX, pp. 106-107.
1942. *M. nepaeformis* Kevan, Proc. Royal Ent. Soc. London, (a) 17, pts. 10-12, p. 110.

Also referring to this species:

1835. *Mononyx raptorius*, Burmeister, Handbuch der Entomologie, Bd. 2, Abteil. 1, p. 201. (*nec.* Fabricius)
1853. *M. raptorius* Herrich-Schäffer, Die Wanzenartigen Insecten, IX, p. 27, t. 291, fig. 895.
1843. *Mononyx raptorius*, Amyot et Serville, Histoire Naturelle des Insectes, Hémiptères, p. 425. (*nec.* Fabricius)
1854. *Mononyx bipunctatus* Stål, Ofversigt af Kongl. Vetenskaps-Akademiens Fordhandlingar, no. 3, XI, p. 239.
1858. *M. bipunctatus* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, 2, p. 82.
1859. *M. bipunctatus* Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischen Verein zu Stettin, p. 53.
1863. *M. bipunctatus* Stål, Berliner Entomologische Zeitschrift, VII, p. 405.

Size. Male: Length, 7.6 to 7.9 mm.; width of pronotum, 5.0 to 5.3 mm.; width of abdomen, 5.3 to 5.4 mm. Female: Length, 7.9 to 9.1 mm.; width of pronotum, 5.5 to 6.1 mm.; width of abdomen 5.5 to 6.2 mm.

Color. Yellowish-brown to reddish-brown, usually the former; a dark brown spot at distal end of embolial suture, a black spot medially at posterior margin of head; segments of connexivum with a thin dark area at the anterior margin; front femora yellowish-brown, darker on the posterior third; intermediate and hind legs yellowish ringed with brown; abdominal segments brown with spots of yellow, especially along the lateral margins.

Structural characteristics. Apex of head more or less pointedly projecting, terminating in a pair of apical tubercles; lateral tubercles of the head smaller, separate and four or five in number on each side of the head. Pronotum widest at a level of the transverse furrow, about as wide as abdomen, projecting beyond base of embolium; lateral margins of the pronotum irregular in shape, usually with the median part straight or faintly rounded, the anterior and posterior parts straight or slightly sinuous and converging sharply toward the eye and base of embolium respectively; posterior margin nearly straight, weakly sinuated before scutellum. Scutellum without noticeable tumescences and a slight depression on either side of the median line of the body. Hemelytra extending to the end of the abdomen; embolium rather dilated, lateral margin more or less rounded. Connexivum prominent in both sexes, but especially so in the female. Ninth abdominal sternite of the male small, oval, two-thirds as long as wide, longer than eighth abdominal sternite; abdominal sternites asymmetrical. Abdominal sternites of the female almost symmetrical; last visible abdominal sternite medially roundly emarginated, a shallow depression on either side of emargination laterad of which is a small tumescence. Ovipositor lobes large, elongate. Clasper of the male sickle-shaped, simple, a slight constriction present just before apex making the apex bluntly spatulate; aedeagal furrow visible on the ventral surface for only a short distance at the apex.

Location of type. Unknown. Doctor H. B. Hungerford examined a specimen of this species in the Kiel Museum, Kiel, Germany in 1928. He states in his notes that the specimen is a female "with Fabr. label."

Distributional data. The literature gives this species a rather extensive range. Specimens from Mexico to Chile have been identified as this species. All the specimens examined by Melin, with the exception of one nymph which was questionably identified as belonging to this species, were from Brazil. This worker has examined specimens from the following localities:

Brazil: Bahia, no date, Rolle, 1 female, (CAS); Vic. João Pessoa (São Phelipe), River Juruá, July 10 to Sept. 20, 1936, A. M. Olalla, 1 female; Jurujuba, Rio de Janeiro, Jan. 6, 1920, E. G. Holt, 1 female; Nova Friburgo, May, 1935, D. M. Cochran, 1 female, (USNM); Nova Teutonia, May 15, 1935, F. Plaumann, 1 male and 1 female, (Usinger Coll.); Rio de Janeiro, Mar. 4, 1935, P. Sandig, 1 female, (USNM); Rio, no date, P. R. Uhler, 1 female, (USNM); São Paulo, no date, Marz., 7 males and 12 females, (Mus. Prague); "Braz.," no date, P. R. Uhler, 1 male, (USNM).

Paraguay: Horquaeta, 45 mi. E., Aug. 7, 1933, A. Schulze, 1 female, (J. C. Lutz Coll.); same place, July 10, 1934, A. Schulze, 1 female, (J. C. Lutz Coll.); Santa Barbara, Dec. 8, 1924, F. Schade, 1 female; Villarrica, Aug. 30, 1923, F. Schade, 1 male.

Argentina: "Argentina," no date, Weiser, 1 male, (Mus. Prague).

Comparative notes. This species resembles *N. terrestris* (Kevan) and *N. tenebrosa* n. n. It can be separated from the former by the small size of the ninth abdominal sternite of the male and by the rounded emargination of the posterior margin of the last visible abdominal sternite of the female. It can be separated from the latter species by the dilation of the embolium and by the more symmetrical abdominal sternites of the female.

Nerthra terrestris (Kevan)

(Pl. VII, fig. 48; Pl. VIII, fig. 62; Pl. X, fig. 87)

1948. *Mononyx terrestris* Kevan, Annals and Magazine Nat. Hist., 11th series, vol. 14, no. 119, p. 813. (n. n. for *M. bipunctatus* Melin).

Referring to this species:

1929. *Mononyx bipunctatus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 177, figs. 39-42, 108.
1942. *M. bipunctatus*, Kevan, Proc. Royal Ent. Soc. London (a) 17, pts. 10-12, pp. 109-110.

Size. Male: Length, 8.0 to 10.8 mm.; width of pronotum 5.2 to 6.7 mm.; width of abdomen, 5.1 to 6.9 mm. Female: Length, 8.5 to 11.1 mm.; width of pronotum, 5.4 to 7.0 mm.; width of abdomen, 5.8 to 7.5 mm.

Color. A yellowish-brown to reddish-brown, median portion of pronotum and scutellum darkest; a blackish spot at the medial end of nodal furrow of the hemelytra; segments of the connexivum dark brown at the anterior half, yellow or yellowish-brown at the posterior half; base of femur and trochanter of fore leg light; femora of intermediate and hind legs light with darker rings, the basal ring of the femur of the hind leg often very faint; tibiae and tarsi of

intermediate and hind legs dark brown; abdominal segments dark brown mottled with yellowish-brown; anal flaps of female yellowish-brown.

Structural characteristics. Apex of the head more or less pointedly projecting, terminating in a pair of sharp tubercles which are sometimes blunt or even rudimentary; lateral tubercles small, separate and four or five in number. Pronotum laterally projecting at a level with the transverse furrow; lateral margin often strongly crenulated, anterior part usually not sinuated but rounded, posterior part often sinuated, usually forming an obtuse angle with base of embolium; posterior margin before scutellum slightly sinuated. Scutellum large, sides sinuated at the base and near the apex; without noticeable tumescences, but a weak depression on either side of median line. Hemelytra extending beyond tip of abdomen in the male, about the same length as the abdomen in the female; embolium with lateral margin sometimes sinuated at the base, usually straight to slightly rounded; nodal suture longer in proportion to the length of the embolium in the female than in the male; connexivum barely visible in the male, prominent in the female. Ninth abdominal sternite of the male very large and broad, nearly twice as long as the eighth abdominal sternite, about two-fifths as wide as fifth abdominal sternite. Last visible abdominal sternite of the female with posterior margin, medially, pointedly notched, nearly symmetrical. Clasper of male sickle-shaped, simple, tapering to a rather blunt point; aedeagal furrow wide, visible on the apical half of the ventral surface.

Location of type. In the Museum of Stockholm, Stockholm, Sweden.

Distributional data. Melin examined specimens from Perú, Bolivia, Brazil, French Guiana, Trinidad, and Mt. Roraima, (Venezuela ?). The writer has seen specimens from the following localities:

Perú: Roque near Moyobamba, Aug. 31, 1923-1925, D. Melin, 1 male and 1 female (types) (Mus. Stockholm).

Bolivia: "Bolivien," no date or collector, 1 male.

Colombia: Metá Villavicencio, May 11, 1946, E. A. Chapin, 1 male, (USNM).

Brazil: Corumbá, April, no collector, 2 females, (Car. Mus.); Manáos, Aug. 1924, Begnaert, 1 female; São Paulo, no date, A. A. Barbiellini, 1 female, (USNM); "Paramaribo," Oct. 6, 1938, D. G. Geiskes, 1 male; "Brazil," no date or collector, 1 female.

British Guiana: Near New Amsterdam, July 30, 1923, F. X. Williams, 1 male; Demerara, June 25, 1901, R. J. Crew, 1 male, (CAS).

French Guiana: St. Jean, no date, W. Schaus, 1 male, (USNM).

Trinidad: St. Augustine, Sept. 20, 1942, D. K. McE. Kevan, 2 males and 2 females.

Comparative notes. This species is very similar to the following species, *N. borealis* (Melin), from which it may be separated by the more laterally projecting pronotum. The writer has examined the types of both species and it is his opinion that the two forms probably represent the same species. The claspers of the males are very similar, that of *N. borealis* (Melin) being slightly more slender apically. However, until such time as we are in possession of the details of the life histories, ecology, etc., it seems best to treat *N. terrestris* (Kevan) and *N. borealis* (Melin) as distinct species.

The name *Mononyx bipunctatus* Melin is a homonym of *Mononyx bipunctatus* Stål, a synonym of *Nerthra nepaeformis* (Fabricius), accordingly, Kevan, 1948, renamed the species *Mononyx terrestris* n. n.

Nerthra borealis (Melin)

(Pl. VIII, fig. 59)

1929. *Mononyx borealis* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 179, figs. 47-49.

Size. Male: Length, 7.2 mm.; width of pronotum, 4.4 mm.; width of abdomen, 4.7 mm. These are the measurements of the type, they vary slightly from the measurements given for the type by Melin.

Color. Dark yellowish-brown, pronotum and scutellum darker than hemelytra; a dark brown spot on the embolial suture at the junction with the nodal suture; posterior margin of the pronotum with thin, longitudinal, black marks; posterior margin of front femur dark brown, the rest yellowish-brown; intermediate and hind legs yellowish with darker rings on the femora, two rings on the femur of the intermediate leg, one on the femur of the hind leg; last three abdominal segments yellowish-brown, the rest of abdomen dark brown; segments of the connexivum mostly dark brown with indistinct light spots near the posterior margins of the segments.

Structural characteristics. Apex of the head more or less pointedly projecting, terminating in two small apical tubercles; lateral tubercles of the head irregularly spaced between apical tubercles and eyes. Pronotum not very dilated laterally, less than the abdomen

in width; lateral margin nearly straight, slightly sinuated at the middle; posterior margin before scutellum moderately sinuated. Scutellum large, without tumescences and a very faint depression on either side of the median line. Hemelytra extending to end of abdomen; embolium slightly dilated, lateral margin weakly rounded. Abdominal sternites of male like those of *N. terrestris* (Kevan); last abdominal sternite large, longer than eighth abdominal sternite and about two-fifths as wide as the fifth abdominal sternite.

Location of type. In the Museum of Stockholm. Stockholm, Sweden.

Distributional data. This unique specimen is from Brazil, no date, Boucord (Mus. Stockholm).

Comparative notes. Very near *N. terrestris* (Kevan), but differing by having the lateral dilation of the pronotum weak, the lateral margin of the pronotum nearly straight.

Nerthra tenebrosa n. n.

(Pl. VII, fig. 50; Pl. VIII, fig. 61; Pl. X, fig. 92)

1929. *Mononyx obscurus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 178, figs. 43-46.

Size. Male: Length, 8.3 to 8.5 mm.; width of pronotum, 5.5 to 5.6 mm.; width of abdomen, 5.3 to 5.8 mm. Female: Length, 8.7 to 9.7 mm.; width of pronotum, 5.8 to 6.2 mm.; width of abdomen, 5.9 to 6.5 mm.

Color. Variable as in the other species from a yellowish-brown to reddish-brown; a dark brown spot at the distal end of the embolial suture; a small, medial, black spot on the posterior margin of the head; posterior margin of the pronotum with small irregular spots of brown; segments of the connexivum dark brown or with the posterior third yellowish; trochanter and base of femur of fore leg, femora of intermediate and hind legs yellowish; femora of intermediate and hind legs ringed with brown; abdominal segments either entirely dark brown or spotted with yellowish-brown.

Structural characteristics. Apex of head more or less pointedly projecting, terminating in a pair of apical tubercles; lateral tubercles of the head small, separate, four or five in number. Pronotum widest at a level with the transverse furrow; lateral margin projecting beyond base of embolium; anterior three fourths of lateral margin nearly straight, usually slightly convex; posterior fourth straight, extending obliquely to base of embolium; posterior margin sinuated before scutellum. Scutellum large, without lateral tumes-

cences; a faint depression on either side of median line of the body. Hemelytra extending to or beyond the end of the abdomen in the males and some females, but shorter than abdomen in some female specimens; embolium sinuated at basal third. Abdominal sternites of male asymmetrical; ninth sternite small, slightly wider than long, longer than eighth sternite. Abdominal sternites of female asymmetrical; posterior margin of last visible abdominal sternite deeply and roundly notched medially; last visible abdominal sternite very long, nearly as long as wide; area about notch pinched up as a result of the narrowing; a prominent depression on either side of the notch, laterad of which is a moderate tumescence, the one on the left slightly the larger. Clasper of the male sickle-shaped, simple, rather abruptly curved and pointed at the apex; aedeagal furrow visible on the apical half of the ventral surface.

Location of type. In the Museum of Stockholm, Stockholm, Sweden.

Distributional data. Melin examined specimens from Mexico, Colombia and Bolivia. The writer has seen specimens from the following localities:

Colombia: Bogotá, not date, Lindig., typus male and allotypus female, (Mus. Stockholm); Cali, no date, W. F. H. Rosenberg, 2 females, (USNM); Gallegos, 1937, no collector, 1 female, (USNM); Medellín, 1938, no collector, 1 female, (USNM); Minca, May, 1919, no collector, 1 female, (Car. Mus.); Muzo, no date, H. Apolimar-Maria, 1 male, (CAS); Río Dagua, no date, W. F. H. Rosenberg, 1 male, (USNM); Río Frío, Feb., 1924, W. M. Mann, 1 male and 4 females, (USNM).

Ecuador: Santa Inéz, no date, R. Haensch, 1 male, (CAS); Tena, Feb. 23, 1923, F. X. Williams, 1 male and 2 females.

Panama: Colon, no date, P. R. Uhler, 1 male, (USNM); same place, no date, C. F. Baker, 1 male, (USNM).

British Honduras: Punta Gorda, Feb., 1931, J. J. White, 1 male, (J. C. Lutz Coll.).

Comparative notes. This species may be separated from *N. nepaeformis* (Fabricius) by the embolium being sinuous at the basal third, by the clasper of the male, and by the asymmetry of the last visible abdominal sternite of the female.

The name *Mononyx obscurus* Melin is a homonym of *Mononyx obscurus* Stål and must be renamed. I propose the new name *Nerthra tenebrosa* for this species.

Nerthra unicornis (Melin)

(Pl. VIII, figs. 57, 57a; Pl. IX, fig. 77)

1929. *Mononyx unicornis* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 179-180, figs. 50-53.

Size. Male: Length, 7.1 to 7.2 mm.; width of pronotum, 4.5 to 4.6 mm.; width of abdomen, 4.5 to 4.6 mm.

Color. Brown to reddish-brown; a dark brown spot at the distal end of the embolial suture; posterior margins of the connexivum, intermediate legs, hind legs and abdominal segments with yellowish-brown areas.

Structural characteristics. Apex of head pointedly projecting, terminating in a pair of sharp apical tubercles, fused medially, the degree of fusion variable in the different specimens; lateral tubercles small, irregular, forming an indistinct toothlike protuberance before the eye. Pronotum very slightly projecting laterally beyond the base of embolium, widest at a level with the transverse furrow; lateral margins nearly straight for the anterior three-fourths, slightly sinuated before scutellum. Scutellum moderately large, a weak tumescence on either side and a slight median longitudinal carination present. Hemelytra extending to or beyond end of abdomen; embolium elongate, lateral margins nearly straight or slightly convex. Connexivum almost covered by the hemelytra. Body covered with slightly clavate bristles, a group of black bristles on the tumescences of the scutellum either in oval patches or short irregular longitudinal bands. Abdominal sternites of male asymmetrical; ninth sternite small, almost identical with the abdominal sternites of *N. nepaeformis* (Fabricius). Clasper of male also resembling that of *N. nepaeformis* (Fabricius).

Distributional data. Melin studied specimens from French Guiana and Brazil. The writer has examined the type, a male from São Leopoldo, Brazil, no date or collector, (Mus. Stockholm) and another male from Pará, Brazil, no date or collector, (Car. Mus.).

Comparative notes. N. unicornis Melin seems to the writer to be very near *N. nepaeformis* (Fabricius). It differs from the latter species by the fusion of the apical tubercles, by the less dilated pronotum and by a slight difference in the shape of the male clasper. The writer unfortunately has not been able to examine a female of this species.

Nerthra peruviana (Montandon)

(Pl. VII, fig. 47; Pl. VIII, fig. 65; Pl. X, fig. 83)

1905. *Mononyx peruvianus* Montandon, Annales Musei Nationalis Hungarici, vol. III, p. 403.
1909. *M. peruvianus* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 182.
1929. *M. peruvianus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 180, figs. 54-57.
1931. *M. peruvianus* De Carlo, Revista de la Sociedad Entomologica Argentina, III, no. 17, p. 329.

Size. Male: Length, 6.9 to 7.3 mm.; width of pronotum, 5.0 to 5.3 mm.; width of abdomen, 5.0 to 5.3 mm. Female: Length, 7.4 to 8.3 mm.; width of pronotum, 5.4 to 6.0 mm.; width of abdomen, 5.6 to 6.8 mm.

Color. Uniformly yellowish-brown to reddish-brown above with a dark spot at junction of embolial and nodal sutures. Ventrally slighty darker. Front femur pale yellow to light brown, lighter than the trochanter. Intermediate and hind legs mostly dark brown, with a lighter area at the base of the femora, occasionally the legs are light with dark rings.

Structural characteristics. Apex of the head more or less projecting with a fairly large pair of sharp-pointed tubercles at apex; lateral tubercles smaller, separate, four or five in number. Pronotum with lateral margins rounded, occasionally with anterior third and posterior fourth straight to slightly concave. Pronotum of male as wide as abdomen, not as wide as abdomen in females. Scutellum with two longitudinal bands of long narrow black bristles. Bristles of the body numerous, small, light brown, not swollen apically. Hemelytra well developed, extending to or beyond end of abdomen. Abdomen of female prominently expanded laterally. Abdominal sternites of male asymmetrical; ninth sternite rounded in shape, longer than seventh or eight sternite. Abdominal sternites of female nearly symmetrical. Posterior margin of last visible addominal sternite medially emarginated with a slightly lateral depression on either side, laterad of which is a moderate tumescence, the one on the left slightly larger than the one on the right.

Location of type. In the Budapest Museum, Budapest, Hungary.

Distributional data. This species has been reported from Perú and Argentina. Specimens from the following localities have been examined by this worker:

Perú: Callango, no date or collector, 9 males and 11 females, one compared with the type by Doctor H. B. Hungerford, in 1928; Chanchamayo, no date, W. F. H. Rosenberg, 1 female, (USNM);

Rioja, Dept. San Martín, Sept. 9 to Oct. 3, 1936, F. Woytkowski, 1 male and 1 female; Río Perené and Chanchamayo, Dept. Junín, May, 1934, F. Woytkowski, 1 male and 1 female; Sani Beni, Dept. Junín, Nov. 9, 1935, F. Woytkowski, 1 female; San Pedro, May 29, 1935, F. Woytkowski, 4 males and 1 female; "Perú," no date or collector, 1 female, (Mus. Prague).

Ecuador: Tena, Apr. 13, 1923, F. X. Williams, 1 male and 1 female.

Bolivia: Huachi, Río Beni, Sept. 1921, W. M. Mann, 1 male, (USNM).

Comparative notes. This species is easily recognized by the longitudinal bands of long, narrow black bristles on the scutellum, the abdominal sternites of the female and the clasper of the male. Of the specimens examined only one specimen lacked the bristles on the scutellum, apparently having been rubbed off in pinning the specimen.

Nerthra montandoni (Melin)

(Pl. VIII, figs. 55, 55a; Pl. X, fig. 85)

1929. *Mononyx montandoni* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 195, fig. 95.
1942. *M. montandoni* Kevan, Proc. Royal Ent. Soc. London (a), 17, pts. 10-12, p. 110.

Size. Male: Length, 5.5 to 5.8 mm.; width of pronotum, 3.7 to 4.1 mm.; width of abdomen, 3.7 to 4.1 mm. Female: Length, 5.5 to 6.1 mm.; width of pronotum, 3.8 to 4.1 mm.; width of abdomen, 3.9 to 4.3 mm.

Color. Yellowish-brown, spotted with small brown markings; a dark brown spot at the distal end of the embolial suture; a blackish spot at median part of posterior margin of head; segments of connexivum dark brown anteriorly, pale yellowish posteriorly; ventral surface more or less light yellow; front femora, rings on intermediate and hind femora and spots on the abdomen brown.

Structural characteristics. Apex of the head concavely excavated with a blunt tubercle on either side of the excavation; lateral tubercles of the head small, blunt and irregularly spaced. Pronotum about as wide as abdomen, less than width of abdomen in some specimens; lateral margins more or less rounded very slightly projecting beyond the base of the embolium; posterior margin prominently sinuated before scutellum. Scutellum fairly large, somewhat elevated; a moderate tumescence on either side and a weak median longitudinal carination present. Hemelytra extending to or

beyond end of abdomen; embolium elongate, narrow with lateral margin slightly rounded. Rather large, clavate bristles scattered over body, more or less clumped; a narrow longitudinal band of black clavate bristles on tumescences of the scutellum. Abdomen posteriorly broadly dilated laterally, rather truncate. Abdominal sternites of male asymmetrical; ninth sternite oval, slightly wider than long, about the same length as eighth sternite or slightly longer. Abdominal sternites of female slightly asymmetrical; posterior margin of last visible abdominal sternite emarginated medially, notch more or less triangular in shape; a slight depression on either side of notch laterad of which is a moderate tumescence, the one on the left the larger. Clasper of male simple, apical part more or less wedge-shaped, directed mesad.

Location of type. Holotype, female, in the Museum of Stockholm, Sweden. Allotype, male, Icta, Trinidad, XI- 19- 1941, N. Hynes, in the Francis Huntington Snow Entomological Museum at the University of Kansas.

Distributional data. Melin examined two females of this species from Venezuela. The writer has before him three specimens from Trinidad. One male and one female from Icta, Nov. 19, 1941, N. Hynes; the other a male, merely labeled "Trinidad, W. I.," Dec. 14, 1902, Chipman, (CAS).

Comparative notes. Melin said this species was near *N. ranina* (Herrich-Schäffer), but the abdominal sternites of the female are entirely different. The species may be separated from *N. peruviana* (Montandon) by the concavely excavated apex of the head. The male can be separated from both species by the shape of the clasper.

Melin had only the females of this species before him when he described this species, therefore, I designate the male specimen from Icta, Trinidad, Nov. 19, 1941, N. Hynes, as the allotype of this species.

Nerthra americana (Montandon)

(Pl. XII, fig. 115; Pl. XIII, fig. 120)

1905. *Matinus americanus* Montandon, Annales Musei Nationalis Hungarici, vol. III, pp. 404-405.
1906. *M. americanus* Torre-Bueno, Proc. Ent. Soc. Washington, vol. VIII, nos. 1 and 2, p. 51.
1931. *M. americanus* Carlo, J. A. de and Gemignani, E. V., Revista de la Sociedad Entomologica Argentina, vol. 3, no. 6, pp. 329-330.

Size. Male: Length, 6.3 to 6.6 mm., width of pronotum, 4.3 to 4.4 mm., width of abdomen, 4.4 mm. Female: Length, 6.6 to 7.1 mm., width of pronotum, 4.5 to 4.9 mm., width of abdomen, 4.6 to 5.1 mm.

Color. Above, yellowish-brown to brown, scutellum and disc of pronotum usually darker; basal two thirds of each segment of the connexivum dark brown; hemelytra and lateral expanses of pronotum are sometimes spotted with dark brown. Below, legs light with dark brown rings, front femora irregularly spotted with brown; abdominal segments of female dark, but may be spotted with yellowish-brown; ovipositor lobes of female and last two abdominal segments of the male, lighter than rest of abdominal segments.

Structural characteristics. Apex of head pointedly projecting, anterior margin with numerous small, sharp-pointed tubercles; ocelli absent. Lateral margins of pronotum subparallel for the posterior two thirds, straight or very faintly concave and slightly converging anteriorly; anterolateral margin converging abruptly toward the eye, rather concave; posterolateral margin doubly concave; posterior margin nearly straight, with three broad, very shallow, concavities; disc elevated, lateral expanses nearly flat, slightly elevated medially next to disc; pronotum and abdomen subequal in width in males, abdomen slightly wider than pronotum in female. Scutellum not at all elevated, no higher than hemelytra and depressed slightly at base, the apex being the most elevated portion. Hemelytra usually extending as far as or beyond end of abdomen, entirely coriaceous and fused together; embolium with basal portion expanded laterally, and bent up for about one half its length. Connexivum visible, more expanded laterally in females. Bristles of dorsal part of body, moderately long and clavate, those of the hemelytra darker than rest. Abdominal sternites of female nearly symmetrical; emargination of posterior margin of last visible sternite nearly triangular, slightly rounded apically; ovipositor lobes triangular, slightly longer than wide; caudolateral angles of last visible sternite weakly projecting posteriorly. Ninth abdominal sternite of male oval, with oblique furrow from left to right, wider than long, 33:19, longer than seventh or eighth sternites; right side of seventh sternite completely covered by the sixth sternite. Clasper of male distinctive, sickle-shaped, but with a large thumblike projection arising on the dorsolateral surface.

Location of type. Unknown. It may be in the National Museum of Hungary at Budapest, some of the specimens before the author at the time of the description were from this museum. The rest of the specimens were from Montandon's own collection, but Dr. H. B. Hungerford did not find this type in the British or Paris Museums.

Distributional data. Montandon's specimens were from Espírito

Santo, Brazil. Specimens studied by this worker are from São Paulo, Brazil, no date, Mraz. Lgt., 2 males and 13 females. The specimens belong to the Museum of Prague, Prague, Czechoslovakia. A male and female from this series has been retained and are now in the Francis Huntington Snow Entomological Collection at the University of Kansas.

Comparative notes. This species may be separated from *N. williamsi* n. sp. by the right side of the seventh abdominal sternite of the male being covered by the sixth segment, by the smaller size, by the presence of clavate bristles and by the shape of the clasper of the male. It can be separated from the other American species by the absence of ocelli, and by the entirely coriaceous hemelytra which are fused together.

Nerthra williamsi n. sp.

(Pl. XII, fig. 112)

Size. Male: Length, 8.0 to 8.6 mm., width of pronotum, 5.8 to 6.1 mm., width of abdomen, 5.7 to 6.0 mm. Female: Length, 9.1 to 9.6 mm., width of pronotum, 6.4 to 6.8 mm., width of abdomen, 7.0 to 7.1 mm.

Color. Above from light yellowish-brown to brown, base of scutellum, disc of pronotum, front of head, and antero-lateral angles of segments of connexivum, darker. Below, head dark, front legs mostly dark brown or black, irregularly marked with yellow and yellowish-brown, femora of middle and hind legs yellowish-brown, ringed with two bands of dark brown, abdominal segments brown to black, caudolateral angles of each segment lighter in color.

Structural characteristics. Front of head with sharp-pointed tubercles, apical ones ventrad and slightly caudad of others, the latter, of which there are about five on each side, are irregular as to size and position, usually along the anterolateral margin of the head. Apical tubercles variable as to number and size, usually one large median apical tubercle; ocelli absent. Width of pronotum about equal to width of abdomen in males, less than width of abdomen in females; lateral margin of pronotum nearly straight, barely concave, for the posterior three fourths of the margin of the pronotum, abruptly but roundly converging to the eye anteriorly, posterolateral margin rounded; posterior margin of pronotum relatively straight, very weakly concave before scutellum, slight convexities before the basal angles of the scutellum and before base of embolial suture of hemelytron; disc elevated, lateral expanses of pronotum nearly

flat. Scutellum, not especially elevated, except at apex; base sunken, inclined posteriorly to apex. Hemelytra entirely coriaceous, fused together. Connexivum expanded laterally in both sexes, wider than embolium, but more so in females. Body covered with slender, brown or black bristles which are slightly curved near apex, pointed, not at all clavate. Abdominal sternites of female with last sternite fairly deeply emarginated, apex of emargination more or less rounded; sternites nearly symmetrical; lobes of ovipositor rather large, triangular, slightly longer than wide and each with a rather deep depression. Ninth abdominal sternite of male small, oval, wider than long, 20:11, about equal to or a little longer than eighth sternite, longer than seventh sternite. Spatulate right side of seventh abdominal sternite, elongate and narrowed. Clasper of male sickle-shaped, quite similar to the clasper of *N. peruviana* (Montandon) and *N. nepaeformis* (Fabricius).

Location of type. Holotype male, allotype female and 3 male and 3 female paratypes, São Paulo, Brazil, no date, Mraz Lgt., in the Museum of Prague, Prague, Czechoslovakia. One male and one female paratype, same data, in the Francis Huntington Snow Entomological Collections at the University of Kansas.

Distributional data. As given for type series.

Comparative notes. This form is closely related to *N. americana* (Montandon), if one considers the hemelytra, it may be separated from this species by the clasper of the male being simple, without a large process on the left side, bristles not clavate, right side of seventh abdominal sternite of male not covered completely by sixth sternite and by the presence of non-clavate bristles. It is the opinion of the writer, that this species is actually closely related to *N. peruviana* (Montandon) as is indicated by the similarities of head, pronotum, abdominal segments, male claspers, non-clavate bristles, etc. It may be distinguished from the latter species by the fused, entirely coriaceous hemelytra and absence of ocelli.

This species is named in honor of F. X. Williams, who has collected considerable material of this family from various regions of the world.

Nerthra amplicollis (Stål)

(Pl. VII, fig. 53; Pl. VIII, fig. 68; Pl. X, fig. 95)

1854. *Mononyx amplicollis* Stål, Ofversigt af Kongl. Vetenskaps-Akademiens Fordhandlingar, Band XI, no. 3, p. 239.
1859. *M. amplicollis* Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischen Verein zu Stettin, p. 53.
1863. *M. amplicollis* Stål, Berliner Entomologische Zeitschrift, VII, p. 406.

1873. *M. amplicollis* Walker, Catalogue of Hemiptera in British Museum, part VIII, p. 172.
1876. *M. ampicollis* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, no. 4, p. 138.
1899. *M. amplicollis* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumaine, an. VIII, nos. 4 and 5, p. 400.
1901. *M. amplicollis* Champion, Biologia Centrali-Americana, Rhynchota Heteroptera, vol. II, p. 350, pl. XX, fig. 26.
1909. *M. amplicollis* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 180.
1929. *M. amplicollis* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 184-185, figs. 65-68, 104, 109.

Size. Male: Length, 10.8 to 12.7 mm.; width of pronotum, 6.8 to 7.7 mm.; width of abdomen, 6.7 to 7.5 mm. Female: Length, 10.5 to 14.7 mm.; width of pronotum, 6.3 to 9.3 mm.; width of abdomen, 6.7 to 9.1 mm.

Color. Brown to black, frequently reddish brown; connexivum entirely dark or with thin pale areas at the posterior margins of the segments; apex of head, front trochanter, anterior and basal part of front femur and a spot near apex of hind femur yellow or orange; posterior margin of front femur, front tibia-tarsus, intermediate and hind legs and abdomen dark brown.

Structural characteristics. Apex of the head broadly concavely excavated; a short broad tubercle on each side of the excavation; lateral tubercles indistinct, forming a slight toothlike protuberance. Pronotum as wide at the anterior third as at the level of the transverse furrow; projecting beyond the base of the embolium, but not as wide as the abdomen; lateral margin with the median third, straight and parallel with the longitudinal axis of the body, anterior third straight obliquely converging to the eye, posterior third straight converging obliquely to the base of the embolium; posterior margin sinuated before the scutellum. Scutellum large, elevated except at the basal angles. Hemelytra extending beyond the end of the abdomen; embolium slightly dilated; lateral margin concave at the base, slightly convex the remainder of its length. Connexivum almost completely covered by the hemelytra in the male, moderately prominent in the female. Abdominal sternites of male asymmetrical; ninth sternite twice as wide as long, longer than eighth sternite and about the same length as the seventh sternite; seventh sternite not visible on the lateral two thirds of the right side. Female abdominal sternites nearly symmetrical; posterior margin of last visible abdominal sternite deeply and pointedly notched. Lobes of ovipositor elongate and rather large. Clasper of the male more or less bifurcate.

Location of type. In the Museum of Stockholm at Stockholm, Sweden.

Distributional data. Kirkaldy and Torre-Bueno list this species from Costa Rica, Colombia, Venezuela, Ecuador and Bolivia. This worker has examined specimens from the following localities:

Costa Rica: San José, no date, M. Valerio, 1 male, (USNM).

Venezuela: Mérida, no date, W. Robinson, 5 males and 3 females, (USNM); same place, no date or collector, 1 female, (AMNH); "Venez.," no date or collector, 1 male and 7 females, (USNM).

Bolivia: "Bolivia," no date or collector, 1 male and 1 female.

Colombia: Cincinnati, Feb. 1924, W. M. Mann, 1 male, (USNM); Fusagasugá, June, 1917, Apolinar Maria, 1 female; Villavicencio, Oct., 1916, A. Maria, 1 male, (CAS); "Colombia," no date, F. C. Nicholas, 1 female, (AMNH); same place, no date, C. F. Baker, 4 females, (USNM); same place, no date or collector, 1 female.

Ecuador: Balzapamba, no date, R. Haensch, 1 male; Río Mapoto, Mar. 24, 1939, F. M. Brown, 1 female, (AMNH); Santa Inéz, no date, R. Haensch, 1 male and 1 female; same place, no date, R. Haensch, 3 males and 2 females, (CAS).

Perú: Lima, no date, Soukup, 1 male, (USNM); same place, no date or collector, 1 female; "Perú," no date, P. R. Uhler, 1 male, (USNM); "Perú," no date or collector, 1 female, (AMNH).

Comparative notes. This is the largest American species, however, it varies considerably in size and thus size alone is not always sufficient to seperate this species from the others. The deep triangular emargination and the large elongate ovipositor lobes which do not overlap anteriorly will separate the females from all other species except *N. ecuadorensis* (Melin) which is smaller, which has the abdomen more broadly expanded laterally than most females of *N. amplicollis* (Stål) and which has the emargination of the last abdominal sternite more rounded than in *N. amplicollis* (Stål). The males of this species have the clasper more or less bifurcate, the two parts of this bifurcation are of approximately the same size and both are sharp-pointed. In this respect it differs from *N. ecuadorensis* (Melin) and *N. ater* (Melin), both of which have the dorsal process greatly reduced and not at all sharp-pointed.

Nerthra ecuadorensis (Melin)

(Pl. VIII, fig. 58; Pl. IX, fig. 73; Pl. X, fig. 86)

1929. *Mononyx amplicollis* var. *ecuadorensis* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 185, figs. 69, 70.

Size. Male: Length, 8.1 to 10.2 mm.; width of pronotum, 5.0 to 6.2 mm.; width of abdomen, 5.2 to 6.2 mm. Female: Length, 8.8 to 10.2 mm.; width of pronotum, 5.6 to 7.0 mm.; width of abdomen, 5.9 to 6.8 mm.

Color. As in *Nerthra amplicollis* (Stål).

Structural characteristics. This species is very similar to the preceding species and differs from that species only in a few respects. It is smaller than *N. amplicollis* (Stål); in the case of the females, the abdomen usually is broader in proportion to the length of the body than in the latter species, however, this is not always true and in the opinion of the writer, it is not a very good character; the emargination of the posterior margin of the last visible abdominal sternite of the female is more rounded than in *N. amplicollis* (Stål); the males are smaller than in the latter species and the clasper differs in that the dorsal process is reduced, it varies slightly in that the process may be more or less cylindrical while in other specimens it is flattened in a radial plane to the longitudinal axis of the clasper.

Location of type. In the Museum of Helsingfors, (Helsinki), Finland.

Distributional data. Melin described this species as a subspecies of *N. amplicollis* (Stål), from two female specimens from Ecuador. This worker has studied specimens from the following localities:

Ecuador: Macas, no date, A. Heyne, 1 male; same place, no date or collector, 2 females; "Normandia," no date or collector, 1 female.

Colombia: "Bet. Queremal and Buenaventura," Feb. 3, 1935, H. F. Schwarz, 1 male, (AMNH).

Perú: Aquaitia, Dept. Loreto, Sept., 1946, F. Woytkowski, 1 male; Vic. Guayabamba, Andes, Dept. Amazonas, Aug. 14-19, 1936, F. Woytkowski, 1 female; Río Perené and Chanchamayo, Dept. Junín, May, 1934, F. Woytkowski, 1 male; Vic. San Pedro, May 29, 1935, F. Woytkowski, 2 females; Tarma, Dept. Junín, March 1-15, 1948, F. Woytkowski, 5 males and 2 females; Tinccochaca, Aug. 8, 1911, Yale Peruv. Exp., 1 male and 1 female, (USNM).

Panamá: Boquete, Chiriquí Prov., March 6, 1923, F. M. Gaige, 1 male.

Comparative notes. This species has been raised from subspecific rank to that of a full species on the fact that the males are consistent in the reduction of the dorsal process of the clasper and in being of a smaller size, and because at the present time there is no evidence that the two forms do not occur in the same localities. It should be pointed out, however, that there is no definite proof that the males before this worker actually are the same species as the females. In the series of specimens a pair was taken at Tinccochaca, Perú, on the same day and 5 males and 2 females were taken at Tarma, Perú, in a fifteen day period. While such evidence is not positive, it is sufficient to consider the two sexes as one species, in view of their morphological similarities.

Nerthra planifrons (Melin)

1929. *Mononyx planifrons* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 186, figs. 74-76.

The writer has not seen *Nerthra planifrons* (Melin), or at least has been unable to identify the species. The original description of the species follows.

"Front of caput fairly even, without medial ridge or knob; medial processes knoblike, well separated; some small, apical knobs appearing between them; lateral ones forming an irregular, toothlike knob before depression, which is rather slightly marked. Structure of pronotum somewhat but not strongly marked; side anteriorly, strongly projecting beyond base of hemelytrae; edge rounded and crenulated, somewhat sinuated in the middle; posterior part not bent angularly; anterior corner forming an obtuse angle; posterior margin before scutellum less sinuated than in *amplicollis*. Scutellum with distinct traces of protuberances. Embolium dilated. Abdomen of female dilated terminally, apically somewhat truncated; 6th segment of female jammed, at posterior margin deeply notched to an acute, somewhat rounded angle; lamellae broadly wedge-shaped. Bristles fine and fairly short.

Coloration blackish-brown; segments of connexivum posteriorly with indistinct light spots; abdomen, ventrally, darkish-brown with posterior corner of segments light; legs dark; femora of 2nd and 3rd pair lighter with traces of dark rings.

Length 10, breadth 6 mm.

Museum of Kobenhavn: 1 female, Parzudaki, Mexico. (type)."

Nerthra ater (Melin)

(Pl. VIII, figs. 56, 56a)

1929. *Mononyx ater* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 185-186, figs. 71-75.

Size. Male: Length, 9.1 to 9.2 mm.; width of pronotum, 5.6 to 5.8 mm.; width of abdomen, 5.7 to 5.8 mm.

Color. Black above, posterior margin of the pronotum and the vertex of the head light brown; much lighter below; legs mainly light yellowish brown; abdomen slightly paler.

Structural characteristics. The writer has examined the type of this species and has found it to be very similar to *Nerthra ecuadorensis* (Melin). It differs from the latter species in color, by the more rounded anterior and posterior portions of the lateral margin of the pronotum and by the shape of the clasper of the male. The clasper of *N. ater* (Melin) has a thin concave plate-like process which is flattened in a tangential plane to the longitudinal axis of the clasper and it is located at the same point of origin as the dorsal arm of the bifurcate clasper of *N. ecuadorensis* (Melin). The abdominal sternites are identical with the abdominal sternites of the latter species.

Location of type. In the Museum of Stockholm, Stockholm, Sweden.

Distributional data. The type is from Bogotá, Colombia. Another specimen, in the Museum of Paris, was questionably placed in this species by Melin. It is from Costa Rica.

Comparative notes. It is the opinion of this writer that this may possibly be only an aberrant specimen of *N. ecuadorensis* (Melin). However, until the other specimen in the Museum of Paris can be studied I prefer to retain this species. There is also a possibility that this species could be the male of *Nerthra rudis* (Melin). If such should prove to be the case, *N. ater* (Melin) would fall as a synonym of the latter species.

Nerthra lata (Montandon)

1899. *Mononyx latus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, An. VIII, nos. 4 and 5, p. 399.
1909. *M. latus* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, Vol. X, p. 181.
1929. *M. latus* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, pp. 186-187, figs. 77-79.

Size. Female: Length, 10.5 mm.; width of pronotum, 6.4 mm.; width of abdomen, 6.5 mm.

Color. Brown, except for the femora of the legs which are pale yellow.

Structural characteristics. Apex of head slightly projecting ventrally, concavely excavated above this projecting part; apex terminating in two small tubercles which are barely visible in a dorsal view. Pronotum not as wide as abdomen; lateral margin more or less rounded, anterior part slightly concave, margin faintly crenulated; posterior margin sinuated before scutellum. Scutellum moderate, with slight lateral tumescences and a weak median longitudinal carination. Hemelytra extending beyond end of the abdomen; embolium concave and narrow at base; a constriction at the nodal suture. Connexivum slightly exposed. Abdominal sternites of the female nearly symmetrical, rather broad; last visible abdominal sternite with posterior margin medially emarginated, anterior part of notch more or less rounded.

Location of type. In the British Museum, London, England.

Distributional data. The type is labeled "Nanegal-Equateur." Melin examined two specimens from Ambato, Ecuador, and Antiochia, Colombia. The writer has seen only the latter specimen. It has, in addition to the locality, the label marked "Schh.," but has no date. It is located in the Museum of Stockholm.

Comparative notes. This specimen seems to fit Montandon's description fairly well, although there are only two small apical tubercles of the head instead of three, and in that the abdomen is not so widely expanded that it can be readily separated from some of the other American species, as Montandon states. Except for the two very small apical tubercles and a slight difference in the shape of the lateral margin of the pronotum, the specimen studied by the writer looks like *N. amplicollis* (Stål) or more especially like *N. ecuadorensis* (Melin). This name must be retained until the type can be examined and compared with the other species.

Nerthra rudis (Melin)

(Pl. X, fig. 90)

Referring to this species:

1929. *Mononyx fuscipes* var. *rudis* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 182, fig. 62.

Size. Female: Length, 8.9 to 10.6 mm.; width of pronotum, 5.3 to 6.4 mm.; width of abdomen, 5.4 to 6.1 mm.

Color. Yellowish-brown to black; scutellum dark brown or black; a small yellow spot at the posterior angle of each segment of the

connexivum; ventral surface light brown or brown with femora of legs, median portion of abdomen and anal flaps yellow.

Structural characteristics. Apex of the head concavely excavated; lateral tubercles forming a moderate toothlike protuberance between the eye and apex of the head. Pronotum widest at a level with the transverse furrow, about as wide as abdomen; lateral margin with the anterior three fourths nearly straight, slightly convex then weakly concave; posterior margin sinuated before scutellum. Scutellum slightly elevated, a depression at each basal angle. Hemelytra extending beyond tip of abdomen; lateral margin of embolium slightly convex. Connexivum moderately exposed dorsally. Abdominal sternite of the female nearly symmetrical; posterior margin of the last visible abdominal sternite medially, deeply and pointedly emarginated; a slight depression on either side of the emargination. Ovipositor lobes large, elongate, the anterior end of the left lobe twisted to the right and covering the anterior end of the right lobe.

Location of type. In the Museum of Helsingfors, Helsingfors (Helsinki), Finland.

Distributional data. The type is from Vera Cruz, Mexico. Another specimen studied by Melin is from Guatemala. This worker has seen specimens from the following localities:

Costa Rica: Río Virilla, Dec. 26, 1931, H. Schmidt, 4 females.

Panamá: Bohio, C. Z., Feb. 7, 1911, E. A. Schwarz, 1 female, (USNM); Buenaventura, Mar. 10, 1911, A. Busck, 1 female, (USNM); XX Plantation, 6 mi. E. Portobelo, Feb. 16, 1930, T. O. Zschokke, 1 female, (CAS).

Ecuador: "Bucay," no date, Campos, 1 female.

Comparative notes. The writer has not seen the type of this species, but the description and the drawings of this species made by Melin could not possibly belong to *N. fuscipes* (Guérin-Méneville). The front of the head, the general shape and especially the shape and size of the ovipositor lobes connect this species to the *amplicollis* group. I take this opportunity to remove this name as a subspecies of *N. fuscipes* (Guérin-Méneville) and elevate it to specific rank. Further study may prove that this is only a subspecies of *N. amplicollis* Stål, but the ovipositor lobes seem to me to be sufficiently different to constitute a good species.

Nerthra corudis n. sp.
(Pl. XV, figs, 144, 145)

Size. Male: Length, 10.0 to 10.4 mm.; width of pronotum, 6.0 to 6.5 mm.; width of abdomen, 6.0 to 6.5 mm.

Color. General coloration above yellowish-brown; head, pronotum and scutellum heavily spotted with darker brown; hemelytra with finer maculations and therefore lighter; segments of the connexivum, yellowish-brown on the posterior two thirds and with apical one third nearly black. Below, nearly uniformly dark brown, nearly black, except caudolateral angles of the abdominal sternites; the eighth sternite has the lighter spot only on the right side.

Structural characteristics. Head with two broad, blunt, superapical tubercles and a broad rather indistinct lateral tubercle on either side. Ocelli present. Pronotum equal to width of abdomen; lateral margin with apical one third roundly converging toward the eyes, the middle one third with the two sides subparallel, slightly convergent anteriorly; pronotum widest at a level with the transverse furrow. Hemelytra with well-developed membranes, extending to end of abdomen; embolium not expanded basally, lateral margin straight or very slightly concave near base, convex at middle. Scutellum broad, not strongly elevated. Bristles very short, slightly clavate, curved, rather sparse. Ninth abdominal sternite oval, twice as wide as long, shorter than eighth sternite; abdomen very distinctly asymmetrical, seventh sternite almost entirely to left side; posterior margins of sternites five and six broadly emarginate to the left side of the abdomen. Clasper of male very characteristic (See fig. 145, Pl. XV).

Location of type. Holotype male, Panzos, Guatemala, no date or collector, in the Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands. Paratype male, same data in the Francis Huntington Snow Entomological Collection, at the University of Kansas, Lawrence, Kansas.

Distributional data. As given above for the type series.

Comparative notes. This species superficially resembles the *fuscipes* group, the abdominal sternites are more like those of the *amplicollis* group. There is a possibility that these specimens could represent the male sex of *N. rudis* (Melin), but the necessary evidence of proof is lacking, so for the present these specimens are described as a distinct species.

Nerthra fuscipes (Guérin-Méneville)

(Pl. VII, fig. 52; Pl. VIII, fig. 63; Pl. IX, fig. 76; Pl. X, fig. 89)

1843. *Mononyx fuscipes* Guérin-Méneville, Revue Zoologique Travaux Inedits, p. 114.
1859. *M. fuscipes* Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischen Verein zu Stettin, p. 53.
1863. *M. fuscipes* Stål, Berliner Entomologische Zeitschrift, VII, p. 406.
1876. *M. fuscipes* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, no. 4, p. 138.
1886. *M. fuscipes* Uhler, Bull. Brooklyn Ent. Soc., p. 27.
1895. *M. fuscipes* Pittier and Biolley, Inst. fisico geografico Nacional (Costa Rica), p. 23.
1899. *M. fuscipes* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, no. 4 et 5, p. 392.
1901. *M. fuscipes* Champion, Biologia Centrali-Americana, Rhynchota Heteroptera, vol. II, p. 348.
1906. *M. fuscipes* Torre-Bueno, Ent. News, vol. 17, p. 54.
1909. *M. fuscipes* Kirkaldy and Torre-Bueno, Proc. Ent. Soc. Washington, vol. X, p. 180.
1910. *M. fuscipes* Montandon, Annuario del Museo Zoologico della R. Università di Napoli (Nuova Serie) vol. 3, no. 10, p. 2.
1917. *M. fuscipes* Van Duzee, Catalogue of Hemiptera, Univ. California Publ., p. 474.
1925. *M. fuscipes* Blatchley, Ent. News, vol. 36, p. 52.
1929. *M. fuscipes* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 181, figs. 58-61.

Also referring to this species:

1853. *Mononyx badius* Herrich-Schäffer, Die Wanzenartigen Insecten, IX, p. 28, fig. 896.
1859. *M. badius* Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischem Verein zu Stettin, p. 53.
1862. *M. badius* Stål, Stettiner Entomologische Zeitschrift, XXXII, p. 459.
1873. *M. badius* Walker, Catalogue of Hemiptera in British Museum, Part VIII, p. 172.
1876. *M. badius* Uhler, Bull. U. S. Geol. Surv., vol. 1, no. 5, p. 337.
1854. *Mononyx obscurus* Stål, Ofversigt af Kongl. Vetenskaps-Akademiens Fordhandlingar, Arg. 11, p. 239.
1859. *M. obscurus* Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischen Verein zu Stettin, p. 54.
1873. *M. obscurus* Walker, Catalogue of Hemiptera in the British Museum, Part VIII, p. 172.

Size. Male: Length, 8.2 to 10.0 mm.; width of pronotum, 5.2 to 6.4 mm.; width of abdomen, 5.2 to 6.5 mm. Female: length, 8.8 to 11.0 mm.; width of pronotum, 5.6 to 6.6 mm.; width of abdomen, 5.7 to 6.8 mm.

Color. Light brown to dark blackish-brown; posterior margins of the segments of the connexivum pale yellowish-brown; two thin blackish-brown spots on the sinuated part of the posterior margin of the pronotum. Ventral surface usually entirely dark brown or with the median part of abdominal segments, posterior lateral angles of the abdominal segments and the apex of the intermediate and hind femora pale yellowish-brown.

Structural characteristics. Apex of the head more or less concavely excavated, a rather broad tubercle on either side of the excavation; lateral tubercles small, generally forming a toothlike protuberance between the eye and the apex of the head. Pronotum widest at the level of the transverse furrow, not quite as wide as the abdomen; lateral margins rather variable, median portion may be rounded, concave or straight, most specimens are of the latter type; posterior margin sinuated before the scutellum. Scutellum rather large, slightly elevated, depressed at the basal angles. Hemelytra extending beyond the end of the abdomen; lateral margin of the embolium usually weakly convex. Connexivum barely visible in the males, moderately prominent in the females. Abdominal sternites of the female nearly symmetrical; last visible abdominal sternite with the posterior margin medianly rather shallowly notched. Lobes of ovipositor small, about as wide as long. Abdominal sternites of the male asymmetrical; ninth sternite small, oval in shape; eighth sternite twice as long as the ninth sternite. Clasper of the male very characteristic, two processes extending mesad from the medial surface.

Location of type. The type was in the Zoological Museum of the University of Naples, Naples, Italy. It is not known to the writer whether the type survived the last World War.

Distributional data. This species was described from a specimen or specimens from Colombia. To present the distribution as given in the literature would be useless in consideration of the fact that no less than five species have been identified as this species by previous workers. Specimens of *N. fuscipes* (Guérin-Méneville) before this worker are from the following localities:

Mexico: Chichén Itza, Yucatán, Aug. 29, 1936, H. D. Thomas, 1 male; Motzorongo, Vera Cruz, Jan., 1892, H. Osborn, 1 male, (USNM); Orizaba, Jan. 17, 1908, F. Knab, 4 males, (USNM); Orizaba, Vera Cruz, Jan. 9-16, 1892, H. Osborn, 1 male, (USNM); Otozac, Nov. 1887, L. Bruner, 1 male, (USNM); "Mexico," no date, Storkan, 1 male, (Mus. Prague).

Guatemala: Cobán, Alta Vera Paz, May 22, 1926, J. M. Aldrich, 1 male, (USNM); Morales, Dec., 1929, J. J. White, 3 males, (J. C. Lutz Coll.); Secanquin, Alta Vera Paz, Jan. 4, 1905, A. Mac Laklan, 1 male, (USNM).

Costa Rica: La Carpintera, Apr., 1924, W. M. Mann, 1 male, (USNM); San Carlos, no date, Schild Bugdorf, 1 male, (USNM).

Honduras: Progresso, Mar. 8, 1923, T. H. Hubbell, 2 females; San Pedro, Sula, no date, W. M. Mann, 1 male, (USNM).

Salvador: La Libertad, Jan. 24, 1930, T. O. Zschokke, 1 female, (CAS).

Panamá: Albrook Field, Canal Zone, Nov. 5, 1937, R. Bliss, 1 male and 1 female, (J. C. Lutz Coll.); Ancón, Canal Zone, May 15-28, 1918, J. Zetek, 1 male, (USNM); Barro Colorado I., Canal Zone, Nov. 22, 1944, K. E. Frick, 1 male, (CAS); same place, Dec., 1946 to Feb., 1947, J. Zetek, 1 male, (USNM); Boquete, Chiriquí Prov., Mar. 7, 1923, F. M. Gaige, 1 female; Canal Zone, Feb., 1923, C. V. Riley, 1 male, (USNM); Cano Saddle, Gatún L., Aug. 6, 1923, R. C. Shannon, 1 male, (USNM); Chilibrillo Caves, Apr. 30, 1945, K. E. Frick, 1 female, (CAS); Colom (Colón ?), "Casey bequest 1925," 1 male, (USNM); Corozal, May 12, 1937, R. Bliss, 1 male, (J. C. Lutz Coll.); Fort Clayton, Canal Zone, Feb., 1945, K. E. Frick, 1 male, (CAS); Fort Kobbe Rd., Canal Zone, May 19, 1937, R. Bliss, 1 female, (J. C. Lutz Coll.); Gatún, Canal Zone, Mar., 1930, T. O. Zschokke, (CAS); same place, no date, A. H. Jennings, 1 male, (USNM); Gatún Dam, C. Z., Apr. 13, 1930, T. O. Zschokke, 2 males and 1 female, (CAS); Gatun Lake, Aug. 16, 1931, T. O. Zschokke, 2 males, (CAS); Paraíso, C. Z., June 5, 1911, A. Busck, 1 male, (USNM); same place, no date, A. H. Jennings, 1 male, (USNM); "Pan.," no date, P. R. Uhler, 1 male, (USNM).

Colombia: Palmira, May, 1943, B. Losada S., 1 male, (USNM).

Brasil: "Rio de Jan." Oct., no collector, 1 male, (Car. Mus.).

Puerto Rico: Ponce, July 10, 1928, L. F. Con., 1 male and 2 females, (J. C. Lutz Coll.).

Comparative notes. The original description of this species is not sufficient to determine accurately this species, however, the description by Montandon, 1899, his confirmation of that description after studying the type, 1910, and specimens determined as this species by Montandon, led the writer to accept Montandon's concept of the species. However, an examination of the male genitalia soon revealed that what Montandon and other workers had considered one species was in reality a complex of at least four closely related species. The question therefore arises as to which of these four species should the name *N. fuscipes* (Guérin-Méneville) be assigned. Since the location of the type is unknown at present, the writer has been forced to base his decision upon geographical distribution. Of the four species, only one species was represented, in

the material studied, from areas as far south as Colombia. This species I am presently calling *N. fuscipes* (Guérin-Méneville).

This species is most closely related to *N. manni* n. sp. and can be separated from that species only by the male genitalia. While the later species appears to occur mainly in Western Mexico, the ranges of the two appear to overlap at the Isthmus of Tehuantepec. Because of this overlap, females from Eastern Mexico, Southern Mexico and Guatemala were not included in the distributional data of either species.

Nerthra manni n. sp.

(Pl. VII, fig. 54; Pl. VIII, fig. 66; Pl. IX, fig. 80)

Size. Male: Length, 9.1 to 10.2 mm.; width of pronotum, 5.6 to 6.1 mm.; width of abdomen, 5.6 to 6.3 mm. Female: Length, 8.8 to 11.0 mm.; width of pronotum, 5.6 to 6.6 mm.; width of abdomen, 5.7 to 6.8 mm.

Color. Light brown to dark blackish-brown; posterior margins of the segments of the connexivum pale yellowish-brown; darker irregular spots on the posterior margin of the pronotum; ventral surface usually entirely dark brown or with the median part of abdominal segments, posterior angles of the abdominal segments, and the apex of the intermediate and hind femora pale yellowish-brown.

Structural characteristics. Apex of the head more or less concavely excavated, a rather broad tubercle which is variable in size on either side of the excavation; lateral tubercles generally forming a toothlike protuberance between the eye and the apex of the head, but sometimes a few are separate between the protuberance and the tubercle that is laterad of the apical excavation; ocelli present. Pronotum widest at the level of the transverse furrow, not quite as wide as abdomen, although this may vary with some specimens; lateral margins variable, median part in particular, either slightly rounded, straight or weakly concave; posterior margin sinuated before the scutellum. Scutellum rather large, slightly elevated, depressed at the basal angles. Hemelytra extending beyond the end of the abdomen in normal specimens; lateral margin of the embolium usually weakly convex. Connexivum barely visible in the males, moderately prominent in the females. Abdominal sternites of the female nearly symmetrical; last visible abdominal sternite with the posterior margin medially rather shallowly notched. Lobes of ovipositor small, about as wide as long. Abdom-

inal sternites of the male asymmetrical; ninth sternite small, about half as long as the eighth sternite. Clasper of the male with one large process or projection on the medial surface, the medial basal angle of the projection deeply sinuate.

Location of types. Holotype male and allotype female, Taxco, Guerrero, Mexico, Oct., 1946, J. G. Shaw; 1 male paratype, La Sabana, Guerrero, Mexico, kil. 226 S. Mexico City, Oct. 20, 1936, H. D. Thomas; 3 male and 9 female paratypes, Tejupilco, District of Temascaltepec, Mexico, June-July, 1933, H. E. Hinton in the Francis Huntington Snow Entomological Collections at the University of Kansas. One male and 2 female paratypes, Tejupilco, Dist. Temascaltepec, Mexico, June 24, 1933, R. L. Usinger and H. E. Hinton; 1 male paratype, Bejucos, Dist. of Temascaltepec, Mexico, July 3, 1933, H. E. Hinton and R. L. Usinger in the R. L. Usinger Collection. One male paratype, Cuernavaca, Morales, Mexico, July, 1945, N. L. H. Krauss; 9 male and 7 female paratypes, Las Barrancas, Mexico, Mar. 1923, W. M. Mann; 13 male and 7 female paratypes, Above Tepic, Nayarit, Mexico, Mar., 1923, W. M. Mann in the United States National Museum at Washington, D. C. One male paratype, Cuernavaca, Morales, Mexico, Nov. 19, 1946, E. S. Ross; 1 male paratype, 3 miles S. Acahuizotla, Guerrero, Mexico, Nov. 17, 1946, E. S. Ross; 1 female paratype, Álamos, Sonora, Mexico, Oct. 2, 1923, H. S. Gentry in the collections of the California Academy of Science at San Francisco, California.

Distributional data. This species appears to be restricted to Mexico, particularly to the western states. It may also possibly occur in the extreme southern portions of California and Arizona since I have seen a specimen from Sonora, Mexico (paratype in the California Academy of Science's collection). I have also seen a female specimen which was taken from the crop of a chicken in Nogales, Arizona. There is no way of knowing where the chicken came from, however, the state of preservation of the specimen would indicate that it had not been in the chicken's crop very long. This specimen is in the Francis Huntington Snow Entomological Collections at the University of Kansas.

Comparative notes. This species can be separated from *N. fuscipes* (Guérin-Méneville) only by the male genitalia. In this species there is a single large medial process while in the latter species there are two smaller medial processes.

This species could have been Herrich-Schäffer's *Mononyx badius* or Stål's *M. obscurus,* however, since this species is apparently

rather restricted to western Mexico, I rather doubt that it was either. The type of the former is apparently lost and the type of the latter may be with other types of Stål in the Museum of Stockholm, Stockholm, Sweden. If it is located there, Melin, 1929, does not mention it.

This species is named for W. M. Mann, Director of National Zoological Park, Washington, D. C., who collected many specimens not only of this species but of many other species in this family.

Nerthra hungerfordi n. sp.

(Pl. VII, fig. 51; Pl. VIII, fig. 60; Pl. IX, fig. 78)

Size. Male: Length, 7.5 to 9.0 mm.; width of pronotum, 5.0 to 5.8 mm.; width of abdomen, 5.0 to 5.9 mm. Female: Length, 8.1 to 9.4 mm.; width of pronotum, 5.5 to 6.0 mm.; width of abdomen 5.8 to 6.4 mm.

Color. Brown to almost black; posterior margin of the pronotum with indistinct alternating black and yellowish-brown spots; connexivum either entirely dark or with a thin yellowish-brown or orange area at the posterior margins of the segments; ventrally mostly dark brown; the forelegs reddish-black; yellowish-brown spots present on the apex of the intermediate and hind femora and on the abdominal segments.

Structural characteristics. Apex of the head more or less concavely excavated, with a tubercle on either side of the excavation; lateral tubercles irregular in size and position, sometimes forming a toothlike protuberance between the eye and the apex of the head. Pronotum widest at the level of the transverse furrow, not as wide as abdomen in the female, about as wide as the abdomen in the male; lateral margins slightly variable in the specimens studied, generally with the median part nearly straight and parallel to the longitudinal axis of the body, anterior third roundly curved to the eye, posterior fourth straight to slightly concave running mesad in an oblique manner to the base of the embolium; posterior margin sinuated before the scutellum. Scutellum rather large, sides and apex slightly tumescent. Hemelytra extending beyond the end of the abdomen in the males, in the females extending to the end or slightly shorter than the abdomen; embolium with lateral margin moderately convex. Connexivum barely visible in the males, moderately so in the females. Body covered by very thin, rather long black bristles. Abdominal sternites of the female nearly symmetrical; posterior margin of the last visible sternite medially shallowly

emarginated. Lobes of ovipositor about as wide as long. Abdominal sternites of the male asymmetrical; ninth sternite small, about half as long as the eighth sternite; eighth sternite over half as wide as fifth abdominal sternite. Clasper of the male somewhat resembling that of *N. fuscipes* (Guérin-Méneville), but with the dorsal surface more irregular, a small dorsal projection present near the bend of the clasper and the medial projections closer to each other.

Location of type. Holotype male, allotype female, and 1 male and 8 female paratypes, Río Virilla, Costa Rica, Dec. 26, 1931, H. Schmidt; 8 male and 9 female paratypes, San José, Costa Rica, 1932, H. Schmidt; in the Francis Huntington Snow Entomological Collection at the University of Kansas. In addition to the above series, there is 1 male and 1 female paratypes, San José, Costa Rica, 1928, M. Valerdo, in the United States National Museum at Washington, D. C.; 1 male paratype, Finca, El Cipres, Suchitepequez Prov., Guatemala, no date. J. R. Slevin, in the Collection of the California Academy of Science at San Francisco, California; and, 1 male paratype, Boquete, Chiriquí Prov., Panamá, Mar. 2, 1923, F. M. Gaige, in the Collection of the University of Michigan at Ann Arbor, Michigan.

Distributional data. Besides the types mentioned above, the writer has studied specimens from the following localities:

Guatemala: Alta Vera Paz, Apr. 30, Schwarz and Barber, 1 male, (USNM).

Nicaragua: "Nicarag.", no date, P. R. Uhler, 1 male, (USNM).

British Honduras: Belize River, Mar. 14, 1922, H. F. Loomis, 1 male, (USNM).

Honduras: Tela, May 23, 1923, T. H. Hubbell, 1 female.

Salvador: La Libertad, Jan. 24, 1930, T. D. Zschokke, 1 female, (CAS); San Andrés, July 25, 1944, E. J. Hambleton, 1 female, (USNM); San Salvador, May 26, 1925, K. A. Salman, 2 males, (USNM).

Costa Rica: Estrella, no date or collector, 1 male, (USNM); Río Virilla, Costa Rica, June to July, 1931, 1 male and 3 females; "Costa Rica," no date, C. F. Baker, 1 female, (USNM).

Comparative notes: This species is closely related to *N. fuscipes* (Guérin-Méneville) and *N. manni* n. sp., but it can be separated from these two species in the case of the males by the shape of the clasper, by the fact that the eighth abdominal sternite of the male is more than half as wide as the fifth abdominal sternite, and by

the slightly smaller size. I name this species after Doctor H. B. Hungerford, under whose supervision this investigation was made.

Nerthra bracchialis n. sp.

(Pl. VII, fig. 45; Pl. IX, figs. 71, 79)

Size. Length 7.0 to 7.7 mm.; width of pronotum, 4.5 to 4.7 mm.; width of abdomen, 4.8 mm. Female: Length, 8.0 mm.; width of pronotum, 5.1 mm.; width of abdomen, 5.2 mm.

Color. Brown to blackish-brown; posterior part of the segments of the connexivum in the female thinly yellow; ventrally mostly dark brown with yellowish-brown spots on the intermediate and hind legs and on the abdomen.

Structural characteristics. Apex of the head more or less concavely excavated, a stout tubercle on each side of the excavation; lateral tubercles of the head forming a toothlike protuberance between the eye and the apex of the head. Pronotum widest at a level with the transverse furrow, slightly less in width than the abdomen; lateral margins more or less rounded; posterior margin before scutellum sinuated. Scutellum large, slightly elevated. Hemelytra extending to or beyond the end of the abdomen; embolium with the lateral margin slightly convex. Connexivum barely visible in the male, prominent in the female. Abdominal sternites of male asymmetrical; ninth sternite small, oval in shape, about half as long as eighth sternite; eighth sternite about half as wide as fifth sternite. Abdominal sternites of the female nearly symmetrical; posterior margin of last visible sternite shallowly notched medially. Lobes of ovipositor about as wide as long. Clasper of the male characteristic; a large projection on the medial surface, medial basal angle of the projection rounded.

Location of type. Holotype male, Mazatlán, Mex., P. R. Uhler Coll. in the United States National Museum at Washington, D. C. Allotype female, Real de Arriba, Dist. of Temascaltepec, Mexico, VII- 6- 33, H. E. Hinton & R. L. Usinger; one male paratype. Tejupilco, Dist. of Temascaltepec, Mexico, VI- 24- 33, H. E. Hinton & R. L. Usinger in the R. L. Usinger Collection.

Distributional data. As given above for the type series.

Comparative notes. This species may be separated from the other three species of this closely related group by the male clasper and the smaller size.

Nerthra grandicollis (Germar)

(Pl. XI, fig. 96)

1837. *Mononyx grandicollis* Germar, Silbermann's Revue Entomologique, V, p. 122.
1859. *M. grandicollis* Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischen Verein zu Stettin, p. 53, 54.
1863. *M. grandicollis* Stål, Berlinger Entomologische Zeitschrift, VII, p. 407.
1873. *M. grandicollis* Walker, Catalogue of Hemiptera in British Museum, pt. VIII, p. 172.
1892. *M. grandicollis* Gerstaecker, Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten, Vol. IX, 2, p. 14.
1899. *M. grandicollis* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, nos. 4 and 5, p. 396.
1899. *M. grandicollis* Horvath, Termeszetrajzi Fuzetek, XXII, p. 268.
1908. *M. grandicollis* Montandon, Herausgegeben von der Kongl. Schwedischen Akademie der Wissenschaften, p. 20.
1914. *M. grandicollis* Montandon, Insectes Hémiptères, II, p. 122.
1925. *M. grandicollis* Singh-Pruthi, Trans. Royal Ent. Soc. London, p. 184.
1926. *M. grandicollis* Jaczewski, Annalibus Zoologicis Musei Polonici Historiae Naturalis, T. V., zesz. 2, pp. 72-74.
1934. *M. grandicollis* Poisson, Bulletin de la Société des Zoologique de France, tome LIX, no. 1, p. 97.
1940. *M. grandicollis* Poisson, Bulletin du Musée royal d'Histoire naturelle de Belgique, tome XVI, no. 40, p. 13.

Also referring to this species:

1865. *Phintius grandicollis* Stål, Hemiptera Africana, III, p. 172.
1876. *P. grandicollis* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, no. 4, p. 139.
1892. *P. grandicollis* Brancsik, Jahrbuche der naturqissenschaftlichen Vereines des Trencsiner Comitates, XV, p. 251.
1853. *Mononyx sordidus* Herrich-Schäffer, Die Wanzenartigen Insecten, IX, p. 26, fig. 893.
1859. *M. sordidus* Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischen Verein zu Stettin, p. 54.
1860. *M. sordidus* Signoret, Annales de la Societe des Entomologique de France, p. 969.
1855. *Mononyx limigenus* Stål, Ofversigt af Kongliga Vetenskaps-Akademiens Fordhandlingar, XII, p. 46.
1859. *M. limigenus* Stål, Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischen Verein zu Stettin, p. 54.
1858. *Mononyx rotundicollis* Signoret, in Thoms. Arch., 2, p. 329, fig. 628.
1929. *Phintius stali* Melin, Zoologiska Bidrag Fran Uppsala, Band 12, p. 193, figs. 100-102, 106. (?)

Size. Male: Length, 7.5 to 9.3 mm.; width of pronotum, 5.5 to 6.3 mm.; width of abdomen, 5.5 to 6.3 mm. Female: Length, 8.2 to 10.4 mm.; width of pronotum, 6.4 to 7.5 mm.; width of abdomen, 6.0 to 7.8 mm.

Color. Variable, from light yellowish-brown to dark brown; connexivum with the posterior half of each segment yellowish-brown, anterior half darker; ventrally mostly dark brown, dilation of front femur, intermediate and hind femora and the abdominal segments either dark or spotted with yellowish-brown.

Structural characteristics. Apex of the head more or less con-

cavely excavated; four tubercles present, three on the frons and one on the apex, the latter is not visible from a dorsal view. Pronotum widest at a level with the transverse furrow, projecting beyond the base of the embolium; lateral margins more or less rounded, converging anteriorly; posterior margin sinuated before scutellum, crossed by nine indistinct longitudinal carinations. Scutellum elevated, tumescent laterally and at the apex. Hemelytra extending to or beyond end of abdomen in the males, usually shorter than abdomen in the females; embolium strongly dilated from the base to the middle, lateral margin of the dilation nearly straight. Connexivum moderately visible in the males, very prominent in the females. Short clavate bristles in groups on the hemelytra, and especially prominent on the tumescence of the scutellum and the carinations of the pronotum. Front femur with anterior margin wavy with toothlike microscopic spines. Abdominal sternites of the female asymmetrical; posterior margin of the last visible abdominal sternite medially deeply notched. Lobes of ovipositor rather large, elongate, rounded posteriorly. Abdominal sternites of the male asymmetrical; ninth sternite about as long as the eighth sternite, twice as long as the seventh, slightly wider than long. Clasper of the male twisted slightly mesad at apex, aedeagal furrow visible for the entire length of the dorsal surface.

Location of type. Unknown. Germar's Hemipterous specimens are located in the Museum of Halle and Dahlem Museum in Germany and Museum of Lomberg in Poland. Doctor H. B. Hungerford visited the Dahlem Museum in Berlin in 1928, and did not find the type there.

Distributional data. This species apparently is the only species of this family present in Africa, where it is found from east to west, south of the Sahara. It also occurs on Madagascar. The writer has studied specimens from the following localities:

Belgian Congo: Ava Kubi, Nov. 10-30, 1909, Lang and Chapin, 1 female, (AMNH); Faradje, Feb., 1911, Lang and Chapin, 1 male, (AMNH); same place, Mar., 1911, Lang and Chapin, 1 female, (AMNH); Garamba, May 3-11, 1912, Lang and Chapin, 1 female, (AMNH); same place, July, 1912, Lang and Chapin, 3 males, (AMNH); Kinda Katana, no date or collector, 1 female; Luebo, D. W. Snyder, no date, 2 females, (USNM); Medjie, May, 1914, Lang and Chapin, 1 male, (AMNH); Niangara, Nov., 1910, Lang and Chapin, 1 female, (AMNH); Parva, July, 1913, Lang and Chapin, 1 male, (AMNH); Panga, Sept., 1914, Lang and Chapin,

1 female, (AMNH); Stanleyville, Mar., 1915, Lang and Chapin, 2 males, (AMNH); same place, Aug. 7, 1909, Lang and Chapin, 1 female, (AMNH); same place, Sept. 5, 1909, Lang and Chapin, 1 female, (AMNH); Vankerckhovenville, April, 1912, Lang and Chapin, 1 female, (AMNH).

Cameroons: Batanga, Mar., 1914, F. H. Hope, 1 male and 1 female, (Car. Mus.); same place, April, 1914, F. H. Hope, 1 male and 1 female, (Car. Mus.); same place, June 15, 1920, F. H. Hope, 1 female, (Car. Mus.); Metet, May 13, 1919, A. I. Good, 1 female (Car. Mus.); Victoria, no date or collector, 2 males and 1 female; Yaunde, no date or collector, 1 male, (Car. Mus.); "N. Kamerun, Johann-Albrechtshohe, L. Conradt, 96", 1 female, (USNM).

Ethiopia: Cheren, Erythraea, no date or collector, 1 male and 2 females.

French Equatorial Africa: Fort-Crampel, no date or collector, 2 females; Gabun, no date or collector, 1 male; Kangwe, no date or collector, 1 male; Lambarene, May, 1892, A. C. Good, 1 male, (Car. Mus); Ogove (Ogowe?) River, no date or collector, 1 male, (Car. Mus.).

Kenya: Diani Dist., 20 mi. S. of Mombasa, Apr. 28, 1948, F. X. Williams, 1 female.

Liberia: Bendija, 1940, W. M. Mann, 1 male, (USNM); Bromley, 1940, W. M. Mann, 1 female, (USNM); Mombo, 1940, W. M. Mann, 1 female, (USNM); Mt. Coffee, Apr., 1897, R. P. Currie, 6 males and 2 females, (USNM); same place, 1897, Mrs. Sharp, 1 male, (USNM).

Mozambique: Delog. Bay (Delogoa Bay), no date or collector, 1 female, (USNM); Lowraulo Margues (Lourenco Margues), no date or collector, 1 male, (USNM).

Nigeria: Ibadan, Apr. 23-May 6, 1936, Van. Zwaluwenburg and McGough, 1 male, (USNM).

Portuguese Guinea: Borma, June to Dec., 1899, L. Fea, 2 females, (USNM).

Sierra Leone: "Sierra Leone," no date or collector, 1 male.

Tanganyika: Lindi, Apr., no collector, 1 male and 1 female; same place, no date or collector, 1 male.

Transvaal: Ugogo, no date or collector, 1 male; Zontpansberg, March, no collector, 1 female; "D. O. Afr., from Rolle," 1 male, (CAS).

Colony Unknown: "Nliosamque, Feb. 1, 1910, Howard Coll.", 1 male and 3 females, (USNM).

Madagascar: Diego-Suarez, 1893, Ch. Alluaud, 1 male, (Mus. Paris); Great Oriental Forest, no date or collector, 2 males; Maro-antsetra, no date or collector, 2 males and 1 female; same place, no date or collector, 1 male and 2 females.

Comparative notes. Most closely related to *N. indica* (Atkinson) from which it may be distinguished by the shape of the dilation of the embolium, more rectangular, by the shape of the clasper of the male, and of course by its peculiar distribution. It is the only species of this genus known from Africa.

Melin, 1929, re-established the genus *Phintius* Stål and described a new species from a single male specimen which is labeled "Mexico-Liebmann." He named this species *Phintius stali.* While it is not impossible, especially in consideration of the distribution of *Nerthra rugosa* (Desjardins), that a species closely related to *Nerthra grandicollis* (Germar) could occur in the New World, I personally feel that it is quite unlikely. It is my opinion that the label has been changed on this specimen. Melin does not state how this specimen differs from *N. grandicollis* (Germar) and his drawings do not show any differences. For these reasons I am temporarily placing this species in the synonomy of *N. grandicollis* (Germar). In the event that an examination of the type proves that this a good species, the name will have to be changed since it is a homonym of *N. stali* (Montandon) which was described much earlier. The original description of *Phintius stali* Melin follows:

"Edge of mouth with a toothlike process; front with s'rongly marked medial knob; medial processes fairly large, knoblike and pointed; lateral ones forming a dentated ridge. Structure of pronotum fairly strongly marked with prominent ridges at transversal furrow, but without stem of T-shaped part; side rounded, level with the furrow, fairly strongly projecting beyond base of embolium; anterior corner hookshaped; posterior margin before scutellum broadly by not very deeply sinuated. Scutellum with traces of protuberances, apical knob very prominent. Processes of femora apically, obtuse-angled and rounded, anterior side wavy. Apical segment in male fairly small, not very much longer than preceding one. Bristles short, conspicuously clavate, densely grouped on sides of scutellum.

"Coloration brownish; abdomen ventrally, darkish-brown with posterior margin of anterior segments lighter; legs light brown;

femora of 1st pair posteriorly, darker; other femora indistinctly ringed.

"Length 9, breadth 6 mm.

"Museum of Kobenhavn: 1 male, Mexico (Liebmann).

"As far as I know, no species of this genus has hitherto been found in the New World. For this reason I thought the label of the specimen might possibly have been changed, but I could not find the type in any paper."

Nerthra indica (Atkinson)

(Pl. XI, fig. 98)

1888. *Mononyx indicus* Atkinson, Journal of the Asiatic Society of Bengal, vol. LVII, pt. 2, p. 345.
1899. *M. indicus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, nos. 4 and 5, p. 397.
1906. *M. indicus* Distant, Fauna British India, vol. III, p. 15.
1919. *M. indicus* Paiva, Records of the Indian Museum, vol. XVI, pt. 5, no. 23, p. 372.

Also referring to this species:

1906. *Mononyx projectus* Distant, Fauna British India, vol. V, p. 310, fig. 174.

Size. Male: Length, 8.4 to 9.1 mm.; width of pronotum, 5.5 to 6.7 mm.; width of abdomen, 5.7 to 6.2 mm. Female: Length, 9.7 to 9.9 mm.; width of pronotum, 7.0 to 7.3 mm.; width of abdomen, 7.2 mm.

Color. Light brown to dark reddish-black; segments of connexivum mostly uniform in color, occasionally with posterior half of each segment lighter. Legs generally light yellowish-brown, abdomen, except for marginal spots, darker.

Structural characteristics. Front of head with four tubercles, three on the frons and one at the apex which is not visible from a dorsal view, the medial tubercle of the frons and the apical tubercle sometimes rather indistinct. Pronotum about as wide at anterior third as at the level with the transverse furrow; lateral margins irregular in shape, usually sinuous, but variable even on the two sides of the same specimen; posterior margin sinuated before scutellum; posterior third of pronotum crossed by nine indistinct longitudinal carinations. Scutellum elevated, tumescent laterally and at apex, a curved ridge paralleling sinuosity of posterior margin of pronotum. Hemelytra extending beyond end of abdomen in the males, not quite reaching end of abdomen in the females; embolium narrow at base, dilated before middle, anterior portion and apex of dilation more or less rounded. Abdomen broadly dilated laterally in the female. Bristles mostly short and clavate, groups of long

black bristles on basal tumescences and median part of pronotum. Abdominal sternites of female nearly symmetrical; last visible abdominal sternite medially emarginated, flattened on either side of emargination. Lobes of ovipositor asymmetrical, slightly lobed and projecting posteriorly. Abdominal sternites of the male asymmetrical; ninth sternite wider than long, not quite as long as eighth sternite but longer than seventh. Male clasper similar to that of *N. lobata* (Montandon) but smaller, not as pointed apically.

Location of type. Unknown. It apparently is not in the British Museum with the rest of Atkinson's specimens.

Distributional data. This species is apparently restricted to India. This worker has seen specimens from the following localities:

Chabua, Assam, Aug. 2, 1943, D. E. Hardy, 1 male, (USNM); Himalaya, 1900, Tulis, 1 female; Kouy-Tcheon, Reg. de Pin-Fa, 1908, Pere Cavalerie, 1 male, (Mus. Paris); Kurseong, no date, P. Blaet, 1 male, (USNM); Sandhira, Sylket, no date, Heidemann, 1 female.

Comparative notes. Most closely related to *N. lobata* (Montandon) from which it may be separated by the male genitalia, by the smaller ovipositor lobes which are less projecting and by the lack of lateral submarginal tumescences of the last visible abdominal sternite in the case of the females. In both sexes the lateral dilation of the embolial margin is not so triangular as in *N. lobata.*

A comparison of the male genitalia of the type of *Mononyx projectus* Distant with the male genitalia of *N. indica* (Atkinson) as identified in this study has shown that they are the same.

Nerthra turgidula (Distant)

1906. *Mononyx turgidulus* Distant, Fauna British India, vol. V, pp. 311-312, fig. 175.

The writer has not seen this species or, at least, has not been able to recognize it.

Original description: "Head, pronotum and scutellum more or less dark greyishly pubescent; hemelytra pitchy black; connexivum greenish ochraceous, with subquadrate piceous segmental spots; head between eyes about twice as broad as long, anterior margin shortly setose and with two short obscure spines at middle; eyes a little recurved, brownish ochraceous, above interiorly fuscous; pronotum with the anterior and posterior margins subequal in breadth, the lateral margins moderately, subtruncately produced, the anterior disk moderately gibbous, but not prominently nodulose,

finely granulose as seen between the pubescence, transversely impressed at about one-third before basal margin, behind this impression longitudinally carinate, the most prominent carinations being six in number, the lateral areas are flatly ampliate, very much less pubescent and more ochraceous in hue, their margins shortly setose, prominently sinuate near anterior angles which are shortly obtusely spinous; scutellum with a short uprightly setose elevation on each side near base, its apex somewhat prominently tuberculous; corium thickly, finely granulose; membrane not reaching abdominal apex; connexivum broad, the posterior angles of the segments moderately angulate, the segments also moderately foveately depressed; body beneath palely fuscously pubescent, the lateral areas of the prosternum more or less ochraceous; abdomen with a lateral fascia on each side united subapically, black in appearance caused by the absence of the paler pubescence; anterior legs fuscously pubescent, the tarsi castaneous at base and black at apex; intermediate and posterior legs more or less olivaceous, shortly setose.

"Length 9.5 millim.; breadth of pronotum 6.5 millim.

"Hab. Nepal; Gowchar (Coll. Dist.)."

This species may very easily be a synonym of *N. indica* (Atkinson), however, it is the opinion of the writer that the species should be retained until such time as the type may be studied and compared to the other species from India.

Nerthra lobata (Montandon)

(Pl. XI, fig. 97; Pl. XV, fig. 138)

1899. *Mononyx lobatus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, nos. 4 and 5, p. 397.

Size. Male: Length, 8.6 mm.; width of pronotum, 6.1 mm.; width of abdomen, 6.2 mm. Female: Length, 10.0 to 10.5 mm.; width of pronotum, 6.8 to 7.0 mm.; width of abdomen, 7.3 to 7.4 mm.

Color. Dorsally dark reddish-brown; segments of connexivum posteriorly yellowish-brown, sometimes entirely dark; front femur mostly dark, anterior dilation and area before apex yellowish-brown; intermediate and hind femora light with a dark brown ring; joint between tibia and femur of all legs black; lateral margins of the abdominal segments yellowish-brown at posterior half.

Structural characteristics. Front of head more or less concavely excavated; a pair of large pointed tubercles on frons, eyes noticeably projecting. Pronotum widest at anterior third; lateral margin

broadly sinuous, two sinuosities before and two behind anterior third; posterior margin sinuated before scutellum; posterior part of the disc of the pronotum crossed by nine indistinct longitudinal carinations. Scutellum moderate in size, elevated, a tumescence at each basal angle and at apex. Hemelytra short not reaching end of abdomen; embolium very narrow at base, suddenly dilated laterally before middle, dilation more or less triangular. Abdomen very prominently dilated laterally. Lobes of ovipositor large, lobed and prominently projecting posteriorly. Bristles on body short and clavate, except those on scutellum which are rather elongate, not very clavate. Bristles on basal tumescences of scutellum very dense and black in color, those on the apex also dense, but light brown in color. Front femur with anterior margin irregular, covered with black toothlike miscroscopic spines. Abdominal sternites of the female slightly asymmetrical, posterior margin of last visible sternite notched medially with a slightly depressed area on each side, laterad of which is a moderate tumescence, the one on the left the larger. Abdominal sternites of the male asymmetrical; ninth sternite rather oval, wider than long, slightly shorter than eighth sternite; seventh sternite about half as long as eighth sternite; fifth sternite very short medially. Male clasper swollen apically, bent mesad, tapering to fairly acute point at apex.

Location of type. In the British Museum, at London, England.

Distributional data. When Montandon described this species he had specimens from Sumatra and Java before him. All specimens examined by the writer have been from Sumatra. They are from the following localities:

Aek Coelangen, N. Harbisaran, Sept. 6, 1928, Meer Mohr, 1 male and 3 females; "Sumatra," no date, R. Weber, 1 female, (AMNH).

Comparative notes. This species is mostly closely related to *Nerthra indica* (Atkinson) but differs from that species in that the abdomen of the female is wider, the ovipositor lobes much more projecting posteriorly, lateral tumescences of the last visible abdominal sternite are present, in the males the clasper while quite similar is not dilated so abruptly as in *N. indica* (Atkinson) and is more sinuous apically and in both sexes the lateral dilation of the embolial margin is more triangular.

It may be that *N. serrata* (Montandon) will prove to be this species in which case *Nerthra lobata* (Montandon) would fall as a synonym since it was described two years after the former

species. Doctor R. L. Usinger examined the clasper of the type of *N. serrata* (Montandon) and is of the opinion that it is the same as my drawing of the clasper of *N. lobata* (Montandon). Montandon's description of *N. serrata* states that the pronotum laterally is very dilated and that the segments of the connexivum are concave. None of the specimens I have examined are of this nature. For that reason and because both species were described by Montandon, this writer prefers to retain both species until more specimens can be examined. The original description of *Nerthra serrata* (Montandon) is given at another point in this work.

Nerthra serrata (Montandon)

1897. *Mononyx serratus* Montandon, Annals Musée Civique di St. Nat. Genova, I, p. 365.
1899. *M. serratus* Montandon, Bulletin de la Société des Science de Bucarest-Roumanie, an VIII, nos. 4 and 5, p. 396.
1906. *M. serratus* Distant, Fauna British India, vol. III, p. 15.

The writer has not seen this species or at least has not been able to recognize it.

Original description: "2. *Mononyx serratus* nov. sp.—Carin Chebà, Carin Ghecù. Collection du Musée Civique de Gênes, du Musée d'hist. Nat. de Hambourg et la mienne.

"Longueur 8.2 - 9.4 mill.; largeur max. pronotum 6 - 7 mill., abdominale 5.8 - 6.8 millimètres.

"Tête fortement tuberculeuse; en regardant l'insecte directement en dessus on aperçoit très bien trois forts tubercules dentiformes en avant, les deux de la partie antérieure de la tête laissent entre eux une assez profonde échancrure au milieu de laquelle se présente le sommet du troisième dont la base est située un peu en arrière des premiers. Cotés lateraux de la tête faiblement sinués crénelés; partie supérieure raboteuse, inégale.

"Pronotum fortement énlargi en demi cercle sur les cotés, le bord externe avec de petites sinuosités formant des dents subarrondies, inégales; dépassant latéralement d'une façon très sensible le niveau du bord externe des élytres et de l'abdomen; l'angle antérieur dirigé presque droit en avant, plus ou moins saillant, parfois assez aigu, atteignant le niveau du milieu transversal de l'oeil.

"Ecusson assez bombé avec une petite carène longitudinale médiane et deux forts tubercules latéraux longitudinaux, un peu divergents en arrière, garnis d'épines dressées en brosse.

"Elytres finement granuleuses, fortement sinuées au bord externe, tout près de la base, cette sinuosité suivie d'un assez fort lobe

aplati, brusquement tronqué en arrière au niveau du tiers basal de l'élytre; subarrondies ensuite sur les deux tiers postérieurs. Connexivum avec tous les segments légèrement sinués, surtout les trois derniers, les angles postérieurs un peu saillants et garnis d'une rangée de petites soies blanchâtres, courtes et raides.

"Tubercule du mesosternum en croix, très atténué au sommet qui est légèrement arrondi, presque aigu. Fémurs jaunâtres pâles avec un anneau indécis, légèrement brunâtre un peu au delà du milieu, et l'extrême sommet étroitement noir brunâtre; tibias et tarses brunâtres, un peu plus clairs vers leur base et plus foncés, presque noirs vers leur extrémité.

"Pièce génitale ♂ assez large, faiblement rejetée sur la gauche. Pièce génitale ♀ un peu plus large que longue, s'enfonçant dans l'échancrure obtuse du dernier segment abdominal; les deux parties de la pièce génitale subtronquées postérieurement avec leur angle externe peu saillant, subarrondi.

"La forme très dilatée du pronotum, le lobe de la marge élytrale et les sinuosités du connexivum permettront de reconnaître facilement cette espèce."

A discussion of the possible relationship of this species with *Nerthra lobata* (Montandon) will be found in the comparative notes of that species.

Nerthra asiatica (Horvath)

(Pl. XIV, fig. 128)

1892. *Mononyx asiaticus* Horvath, Természetrajzi Fuzetek, vol. XV, pt. 3, p. 136.
1909. *M. asiaticus* Oshanin, Verzeichnis der Palaearktischen Hemipteren, vol. 1, p. 956.
1912. *M. asiaticus* Oshanin, Katalog der paläarktischen Hemipteren, p. 89.
1926. *M. asiaticus* Kirit., "Konowia," Zeitschrift fur systematische Insektenkunde unter Mitwirkung fuhrender Entomologen, Vol. 5, No. 3, p. 226.
1930. *M. asiaticus* Kirit., Annuaire du Musée Zoologique de l'Academie des Sciences de l'URSS, p. 435.
1933. *M. asiaticus* Hoffmann, Lingnan Science Journal, vol. 12, Suppl., p. 250.
1935. *M. asiaticus* Wu, Catalogus Insectorum Sinensium, vol. 2, p. 559.
1941. *M. asiaticus* Hoffmann, Lingman Science Journal, vol. 20, no. 1, p. 44.

Also referring to this species:

1899. *Mononyx grossus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, nos. 4 et 5, p. 398.
1906. *M. grossus* Distant, Fauna British India, vol. III, p. 16.

Size. Female: Length, 11.8 mm.; width of pronotum, 8.0 mm.; width of abdomen, 8.5 mm.

Color. Above, more or less uniformly brown, scutellum slightly darker than rest of dorsal surface. Below, mostly dark brown, a

few patches of yellowish-brown about the bases of the middle and hind legs.

Structural characteristics. Apex of head more or less rounded, apical tubercle absent, superapical and lateral tubercles small, irregular in shape, not sharp-pointed. Pronotum widest at transverse furrow, not quite as wide as abdomen; lateral margins parallel or nearly so, in median portion, anterior and posterior parts of the margin distinctly converging mesad; disc elevated and rather rough; posterior margin trisinuate. Scutellum elevated, apex slightly lobed, with tumescences at the middle of the lateral margins. Hemelytra not extending to the end of the abdomen, membrane well developed; embolium with the basal half of the lateral margin nearly straight or very slightly concave, not expanded laterad at middle. Connexivum greatly expanded laterally, wider than width of pronotum or hemelytra. Bristles in rows and clumps on hemelytra and in clumps on scutellum and pronotum, bristles short or moderately long, clavate, slightly curved. Abdominal sternites of female nearly symmetrical, lobes of ovipositor slightly projecting posteriorly; posterior margin of last visible abdominal sternite triangularly emarginate.

Location of type. Unknown. Perhaps in the Museum of Budapest, although Doctor H. B. Hungerford does not mention it in the notes he made during his visit to this museum in 1928.

Distributional data. This species has been reported from China, India and Tibet. The type is from "Flumen Poi-ho," China (G. N. Potanin). This worker has examined a paratype of *Mononyx grossus* Montandon. This specimen is labeled Thibet (Mou-Pin), 1869-1870, (A. David). It was sent in exchange from the Museum of Paris and is now in the Francis Huntington Snow Entomological Collection at the University of Kansas.

Comparative notes. This species differs from *N. indica* (Atkinson) by the shape of the tubercles of the head, by the lateral margin of the pronotum and by the larger size. In the shape of the pronotum it would seem to be cosely related to *N. spissa* (Distant), but the worker has not seen a female of the latter species or a male of *N. asiatica* (Horvath), so no definite comparison can be made between these two species at the present time.

Nerthra spissa (Distant)

(Pl. XI, fig. 101)

1906. *Mononyx spissus* Distant, Fauna British India, vol. V, p. 313, fig. 176.

Size. Male: Length, 8.5 mm.; width of pronotum, 6.0 mm.; width of abdomen, 6.2 mm.

Color. Light grayish-brown, scutellum and median portion of pronotum darker; ventrally darker with faint yellowish-brown spots on intermediate and hind femora and abdominal segments.

Structural characteristics. Front of head with two moderate tubercles. Pronotum nearly rectangular, lateral margins mostly straight, parallel to longitudinal axis of the body, anterior part roundly converging to the eye; lateral margin posteriorly forming almost a right angle with the posterior margin; posterior margin slightly sinuated before scutellum; posterior third of pronotum crossed by two moderate longitudinal carinations. Scutellum with moderate tumescences at lateral sides and apex, median portion depressed. Hemelytra extending beyond end of the abdomen; embolium entirely dilated. Body covered with long erect bristles which are moderately clavate. Abdominal sternites of the male asymmetrical; ninth sternite wider than long, not as long as eighth sternite. Male clasper rather large for the size of the insect, nearly straight, cylindrical, abruptly narrowed to point at apex, twisted, aedeagal furrow obliquely crossing basal half of clasper.

Location of type. In the British Museum at London, England.

Distributional data. Distant described this species from a specimen from Sibsagar, Assam, India. The writer has seen a single male specimen labeled Misamari, Assam, India, June 26, 1943, D. E. Hardy, (USNM).

Comparative notes. Shape of the pronotum, the long erect bristles and the shape of the male clasper easily separates this species from all others.

Nerthra rugosa (Desjardins)

(Pl. XIII, fig. 121)

1837. *Naucoris rugosa* Desjardins, Annals de la Société Entomologique de France, vol. 6, p. 239.
1837. *N. rugosa* Serville, Annals de la Société Entomologique de France, vol. 7, p. 243.
1840. *N. rugosa* Westwood, Introduction to the Modern Classification of Insects, vol. 2, p. 464.
1843. *Peltopterus rugosus* (Desjardins); Guérin-Menéville, Revue Zoologique Travaux Inedits, pp. 112-113.
1863. *P. rugosus* Stål, Berliner Entomologische Zeitschrift, Band. VII, p. 407.
1865. *P. rugosus* Stål, Hemiptera Africana, Band. III, p. 173.

1876. *P. rugosus* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band. 14, No. 4, p. 140.
1900. *P. rugosus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, no. 6, p. 9.
1906. *P. rugosa* Kirkaldy, Trans. Am. Ent. Soc., vol. XXXII, p. 149.
1910. *P. rugosa* Montandon, Annuario de Museo Zoologico della R. Università di Napoli (nuova serie) vol. 3, no. 10, p. 3.

Also referring to this species:

1859. *Mononyx rugosus* (Desjardins); Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischen Verein zu Stettin, p. 53.
1925. *Glossoaspis brunnea* Blatchley, Ent. News, vol. 36, pp. 49-52.

Possibly referring to this species:

1884. *Mononyx stygicus* Uhler, Standard Natural History, vol. II, p. 264, *nec* Say.
1902. *Nerthra stygica* Say; Howard, The Insect Book, pl. XXXIX, fig. 16.

Size. Female: Length, 6.0 to 7.1 mm., width of pronotum, 4.1 to 5.0 mm., width of abdomen, 4.2 to 5.1 mm.

Color. Above; head, disc of pronotum and hemelytra, brown, lateral expansions of pronotum, apical half of the scutellum and apical halves of the segments of the connexivum, yellowish-brown, the lateral portions of the pronotum may have some darker maculations. Below; legs brown; abdomen brown with the caudolateral portions of the segments paler, yellow or yellowish-brown.

Structural characteristics. Front of head with three rounded elevations, apex smooth, rounded, lacking tubercles; ocelli absent. Lateral margins of pronotum subparallel for posterior two thirds, slightly rounded, anterior third roundly converging toward the eyes; posterior angle rounded, not at all projecting beyond base of embolium; posterior margin of pronotum trisinuate before the scutellum. Scutellum rather small, apex rather elongate, tongue-shaped, apex and basal angles slightly elevated, mesobasal portion depressed. Hemelytra entirely coriaceous, fused together, extending to or beyond end of abdomen, smooth, with not a trace of longitudinal carinae, but with a basal and medial tumescence on each hemelytron; embolium greatly expanded laterally at the basal one third, expansion widest posteriorly and rather abruptly narrowing at that point. Connexivum visible, variable as to the degree of expansion. Bristles variable in shape, most of the body with short clavate bristles, elevations with much longer clavate bristles which are very slender at the base. Abdominal sternites of the female symmetrical; last visible abdominal sternite not emarginate, but not covering the ovipositor, usually slightly but broadly keeled. The trochanters of the anterior legs have two apical tubercles in all the specimens examined.

Location of type. In the Museum of Paris, Paris, France.

Distributional data. This small species has without a doubt the most peculiar distribution of all the members of this family. The type was described from "Isle of Maurice" (Mauritius), which is in the Indian Ocean. Blatchley reported it from Florida (as *Glossoaspis brunnea*). The writer has seen specimens from the following localities:

Florida: Arch Cr., Mar. 21, 1911, W. S. Blatchley, 2 females, one the type of *Glossoaspis brunnea* Blatchley, (Purdue Coll.); Biscayne, Apr. 5, 1887, Heidemann, 1 female; Matecumba Key, Mar. 14, 1947, R. H. Beamer, 1 female.

Panamá: San José Is., Pearl Is., Mar. 1, 1944, J. P. E. Morrison, 1 female, (USNM).

Comparative notes. A comparison by Doctor Eugene Seguy of the specimen from Matecumba Key, Florida, has shown that *Glossoaspis brunnea* Blatchley is a synonym of *Peltopterus rugosus* (Desjardins). This species may be separated from the other species, which have the hemelytra entirely coriaceous and fused together and which also have the ocelli absent, in the following ways: From *N. macrothorax* (Montrouzier) and *N. nervosa* (Montandon) by the absence of longitudinal carinae on the hemelytra. From *N. williamsi* n. sp. and *N. americana* (Montandon) by the tubercles of the head and the shape of the last visible abdominal sternite of the female. From *N. hirsuta* n. sp. This species may be separated by the nature of the edges of the hemelytra.

Nerthra macrothorax (Montrouzier)

(Pl. XII, fig. 113; Pl. XIII, fig. 119; Pl. XIV, fig. 135.)

1855. *Galgulus macrothorax* Montrouzier, Annales des Sciences Physiques et Naturelles, d'Agriculture et d'Industrie, Lyon., vol. 2, pp. 110-111.
1863. *Peltopterus macrothorax* Stål, Berliner Entomologische Zeitschrift, vol. VII, p. 407.
1870. *P. macrothorax* Stål, Ofversigt af Kongl. Vetenskaps-Akademiens Forhandlingar, no. 7, p. 706.
1880. *P. macrothorax* Distant, Trans. Ent. Soc. London, pt. IV, p. 486.
1900. *P. macrothorax* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, no. 6, p. 8.
1906. *P. macrothorax* Kirkaldy, Trans. Am. Ent. Soc., vol. XXXII, p. 149.

Also referring to this species:

1861. *Syclaecus macrothorax* (Montrouzier); Stål, Ofversigt af. Kongl. Vetenskaps-Akademiens Forhandlingar, Arg. 18, p. 201.
1865. *S. macrothorax* Stål, Hemiptera Africana, III, p. 173.
1876. *S. macrothorax* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, no. 4, p. 139.

Size. Male: Length, 7.9 mm., width of pronotum, 5.9 mm.,

width of abdomen, 6.0 mm. Female: Length, 9.2 to 10.6 mm., width of pronotum, 6.8 to 8.2 mm., width of abdomen, 6.7 to 8.2 mm.

Color. Above, light brown; the basal portions of the segments of the connexivum, the carinae of the hemelytra and the disc of the pronotum a little darker. Below, brown with a tinge of red.

Structural characteristics. Front of head provided with five large, rounded tubercles, four of which are flattened on top and densely covered with short clavate bristles; ocelli absent. Pronotum greatly expanded laterally; lateral margins converging anteriorly, subparallel for posterior one half; posterior angle projecting obliquely posterolaterad, rather pointed; posterior margin with five concavities. Scutellum, rather small, apex narrowed, basal portion depressed, inclining to apex which is most elevated. Hemelytra entirely coriaceous, fused together, extending slightly beyond end of abdomen, large longitudinal carinae present; base of embolium greatly expanded laterad. Connexivum broadly expanded laterally in both sexes. Entire body covered with short, broadly clavate bristles, bristles pale and especially dense on pronotum and on the elevations of the head. Abdominal sternites of female nearly symmetrical except for posterior margin of last sternite, which is slightly emarginated, but with apex slightly convex just below the lobes of the ovipositor, the latter somewhat rounded and the left one overlapping the right. Abdominal sternites of male rather small, last visible abdominal sternite wider than long, 32:17, nearly twice as long as seventh sternite, which has the right side elongate, spatulate. Clasper of male rather sickle-shaped, but nearly straight, very slightly enlarged at apex (apical third) then tapering to a blunt point.

Location of type: In the Museum of Paris, Paris, France.

Distributional data. This species has been reported from the following places in the East Indies and the Pacific: Philippines, Aru Island, N. Borneo, Woodlark Island, Solomon Arch., and the Mariannes. The writer has examined specimens from the following localities:

New Guinea: Goodenough I., Aligabay Cr., Aug. 1, 1943, B. E. Rees, 1 female, (USNM); Maffin Bay, Dutch N. Guinea, July 1, 1944, E. S. Ross, 1 female, (CAS); same place, May 25, 1944, E. S. Ross, 1 female, (CAS).

Philippines: N. W. Panay, no date, Baker, 1 female, (USNM); Biliran Isl., no date or collector, 1 female, (USNM).

Solomons: Florida Island, Mar. 11, 1945, J. R. Stuntz, 1 male.

Comparative notes. The size, shape of the pronotum, longitudinal carinae and clasper of the male will separate this species from all the others. It is quite closely related to *N. nervosa* (Montandon), but differs in the shape of the pronotum.

Nerthra nervosa (Montandon)

(Pl. XIII, fig. 124)

1900. *Peltopterus nervosus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, no. 6, pp. 8-9.

Size. Female: Length, 8.1 mm., width of pronotum, 5.7 mm., width of abdomen, 6.0 mm.

Color. Dark brown to reddish brown, more or less concolorous, but with the disc of the pronotum, the carinae of the hemelytra, and the scutellum very slightly darker.

Structural characteristics. Front of head with round, flattened tubercles which are densely covered with short clavate bristles; ocelli absent. Lateral margins of the pronotum rounded; pronotum widest at the middle; disc elevated, lateral expansions nearly flat; posterior margin of the pronotum nearly straight, not at all concave before scutellum; pronotum less than abdomen in width. Scutellum rather small, apex narrowed, basal portion depressed, inclining to apex which is the most elevated portion. Hemelytra entirely coriaceous, fused together, extending beyond end of abdomen, longitudinal carinae very large and conspicuous; base of embolium greatly expanded laterally, exceeding or equal to width of pronotum. Connexivum broadly expanded laterally. Bristles of body short and clavate. Abdominal sternites of female nearly symmetrical; posterior margin of last visible abdominal sternite slightly emarginated, last visible sternite not covering the lobes of the ovipositor.

Location of type. In the Museum of Paris, Paris, France.

Distributional data. Montandon described this species from a single male from the Mariannes. This worker has studied a female "Guam, 1895," (USNM), that was determined by Montandon in 1909.

Comparative notes. This species differs from *N. macrothorax* (Montrouzier) in the shape of the lateral margin of pronotum being more rounded, posterior margin nearly straight, smaller size, longitudinal carinae of the hemelytra being somewhat larger and the emargination of the posterior margin of the last visible abdominal

sternite smaller. To the knowledge of the writer, Montandon did not designate this female as the allotype of the species, it may be that he designated some other specimen as the allotype, although I can find no reference to it in the literature. For this reason, it seems best to refrain from designating this specimen as the allotype, at least until more material from some of the European museums can be examined.

Nerthra hirsuta n. sp.

(Pl. XIV, fig. 132)

Size. Female: Length, 6.2 mm., width of pronotum, 4.4 mm., width of abdomen, 4.4 mm.

Color. Brown to dark reddish-brown above, below, darker, except trochanters, bases, and apices of femora of the middle and hind legs, and the posterolateral angles of the ventral abdominal segments which are yellowish-brown.

Structural characteristics. Head with four rather broad toothlike tubercles; ocelli, if present, very small and indistinguishable from the granulation of the head. Lateral margins of pronotum subparallel, but slightly converging anteriorly; anterolateral margin converging rather abruptly toward eye; posterolateral margin rounded. Scutellum moderate in size, depressed basally and elevated laterally from middle to apex. Hemelytra parallel or nearly so for three fifths their length, then converging posteriorly in a broad semicircle; hemelytra thick, entirely coriaceous, fused together and with the costal margins from apex of embolium to apex of hemelytron very distinctly bent up at about a 45 to 60 degree angle to rest of hemelytra, notched at apex and not bent up. Connexivum not visible. Entire upper surface and front of head provided with rather large broadly clavate bristles which are mostly black in color and which are clumped together in spots on the hemelytra and on the elevations of the scutellum. The body as a whole is rather truncate in appearance. Abdominal sternites of the female similar to those of other species from the Australian region, last visible abdominal sternite extending posteriorly and completely or nearly completely covering lobes of ovipositor, broadly keeled and slightly emarginate at apex.

Location of type. Holotype female, West Australia, Augusta, Feb., W. S. Brooks, in the Museum of Comparative Zoology at Harvard University.

Distributional data. As given above for the type.

Comparative notes. This species may be separated from all others with entirely coriaceous and fused hemelytra, by the small size, by the turned-up edges of the hemelytra, and by the abundance of broad, clavate bristles on the dorsal surface and the head.

Nerthra laticollis (Guérin-Méneville)

(Pl. XII, fig. 108; Pl. XV, fig. 139)

1843. *Mononyx laticollis* Guérin-Méneville, Revue Zoologique Travaux Inedits, pp. 112-114.
1863. *M. laticollis* Stål, Berliner Entomologische Zeitschrift, VII, p. 406.
1899. *M. laticollis* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, nos. 4 and 5, pp. 407-408.
1910. *M. laticollis* Montandon, Annuario del Museo Zoologico della R. Università di Napoli (nuova serie), vol. 3, no. 10, p. 2.

Size. Male: Length, 8.4 to 8.5 mm.; width of pronotum, 5.9 to 6.0 mm.; width of abdomen, 5.4 to 5.7 mm. Female: Length, 8.6 to 9.3 mm.; width of pronotum, 5.9 to 6.5 mm.; width of abdomen, 5.5 to 6.2 mm.

Color. Brown to blackish-brown; posterior half of each segment of the connexivum dull yellowish-brown; ventrally mostly dark brown; front femora pale yellowish-brown, femora of other legs slightly darker; posterior half of each abdominal segment near lateral margins with a dirty yellow spot.

Structural characteristics. Five tubercles on front of head, four on frons, one on apex, the latter not visible from above, lateral tubercles of frons smaller than others. Pronotum widest at a point level with the transverse furrow, distinctly projecting beyond the base of embolium, slightly wider than abdomen; lateral margin sinuous, anterior and median portions distinctly concave, posterior portion straight or weakly concave; posterior margin of pronotum sinuated before scutellum; posterior one third of pronotum crossed by five indistinct longitudinal carinations. Scutellum elevated, a moderate oval tumescence at each side and a more obscure elongate median tumescence between them. Hemelytra extending posteriorly beyond end of abdomen, nearly covering abdomen completely in the male, to a lesser extent in the female; embolium elongate, basal one-third narrow and distinctly concave. Bristles short, clavate, forming five groups on each hemelytron, a group on the lateral tumescences of the scutellum and one medial group near anterior margin of pronotum. Mesosternal process moderately pointed at apex, lateral margins straight. Abdominal sternites of the female symmetrical, more or less roundly projecting posteriorly, entirely covering lobes of the ovipositor. Abdominal sternites of male

asymmetrical, ninth sternite much wider than long, slightly less in length than eighth sternite, longer than seventh sternite. Male clasper simple, slightly curved mesad, apical one half distinctly narrowed, aedeagal furrow visible for a short distance at apex.

Location of type. Formerly in the Zoological Museum of the University of Naples, Naples, Italy, the location of the type is now unknown.

Distributional data. Guérin-Méneville in the original description gives the distribution as New Guinea. Montandon also examined specimens from that island. The specimens studied by the writer have all been from New Guinea and are from the following localities:

"Br. N. Guinea," no date or collector, 1 male and 1 female; Finschhafen, Apr. 21, 1944, E. S. Ross, 1 female, (CAS); Lae, N. E. New Guinea, June, 1944, F. E. Skinner, 2 males and 3 females, (CAS); same place, Nov., 1944, Helfer, 1 male; Maffin Bay, "Dutch N. Guinea," Aug. 20, 1944, E. S. Ross, 1 female, (CAS); same place, June 20, 1944, E. S. Ross, 1 female, (CAS); same place, Sept. 1944, E. S. Ross, 1 female, (CAS); same place, July 1, 1944, E. S. Ross, 1 male and 1 female, (CAS); same place, Oct. 7, 1944, E. S. Ross, 1 male, (CAS); Nadyab, Markham R. val., June 1944, K. V. Krombein, 1 male and 2 females, (USNM); "Neth. New Guinea," Dec. 10, 1944, T. Aarons, 2 females, (CAS); "New Guinea," no date or collector, 3 females.

Comparative notes. Near *N. gurneyi* n. sp. from which it can be separated by the sinuous lateral margins of the pronotum and by the shape of the male clasper.

Nerthra gurneyi n. sp.

(Pl. XII, fig. 109)

Size. Male: Length, 9.3 mm.; width of pronotum, 6.3 mm.; width of abdomen, 6:15 mm. Female: Length, 9.7 mm.; width of pronotum, 7.0 mm.; width of abdomen, 6.4 mm.

Color. Light to dark brown above; ventrally entirely dark reddish-brown to blackish-brown.

Structural characteristics. Front of head with two large median tubercles on the frons, laterad of which are a pair of indistinct tubercles, apex with a small tubercle, not visible dorsally. Pronotum widest at a level with the transverse furrow, prominently projecting beyond the base of the embolium, wider than the abdomen; lateral margin more or less rounded, anterior portion slightly con-

cave, converging obliquely toward the eye, medial portion nearly straight, posterior portion straight or very slightly concave, converging obliquely to base of embolium; posterior margin sinuated before scutellum; posterior third of pronotum crossed by two moderate and five faint longitudinal carinations. Scutellum rather large, elevated, sides medially tumescent, a faint longitudinal tumescence medially. Hemelytra extending beyond end of abdomen in male, not quite covering ovipositor lobes in the female; connexivum only slightly visible dorsally; embolium narrow basally, distinctly concave; hemelytra constricted at nodal suture. Groups of clavate bristles present on pronotum, scutellum and hemelytra. Apex of mesosternal process moderately pointed, lateral margins nearly straight. Abdominal sternites of the female symmetrical; last visible abdominal sternite more or less pointedly projecting posteriorly, completely covering lobes of ovipositor. Abdominal sternites of the male asymmetrical; ninth sternite much wider than long, not quite as long as eighth sternite, longer than seventh sternite. Male clasper simple, curved mesad, slightly swollen before apex with short, narrow, fingerlike apex.

Location of type. Holotype male, Bougainville I., July 1 to Sept. 15, 1944, A. B. Gurney in the United States National Museum at Washington, D. C.

Distributional data. As given for the type specimen.

Comparative notes. This species is near *N. laticollis* (Guérin-Méneville) and *N. mixta* (Montandon). Separated from the former by the lateral margin of the pronotum, from the latter by the lesser concavity of the embolium and from both by the shape of the male clasper. The writer has examined a female specimen which he believes to be this species, but since there is not a label on the pin, it seems best not to make this specimen the allotype or even a paratype. This specimen is in the Francis Huntington Snow Entomological Museum at the University of Kansas via the Torre-Bueno Collection.

Nerthra mixta (Montandon)

(Pl. XII, fig. 116)

1899. *Mononyx mixtus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, An. VIII, Nos. 4 and 5, p. 406.
1900. *M. mixtus* Breddin, Senckenbergischen naturforschenden Gesellschaft, Band XXV, Heft 1, p. 175.
1901. *M. mixtus* Breddin, Abhandlungen der naturforschenden Gesellschaft, zu Halle., XXIV, p. 24.

Size. Male: Length, 9.4 mm.; width of pronotum, 7.7 mm., width

of abdomen, 6.5 mm. Female, 9.4 to 9.6 mm.; width of pronotum, 7.7 to 7.9 mm.; width of abdomen, 6.5 mm.

Color. Uniformly dark reddish-brown except for front femora and area about bases of the other legs which are paler.

Structural characteristics. Apex of head provided with five broad toothlike tubercles, apical tubercle ventrocaudad of the others; ocelli present. Pronotum extremely wide, much wider than abdomen; the median portion of the lateral margins more or less rounded, anterior and posterior parts of the margin distinctly converging medially; posterior margin concave before base of the scutellum, convex level with the base of the embolium. Scutellum moderately large, a tumescence on each side and at the apex. Hemelytra extending to or beyond the end of the abdomen; membrane well developed; base of embolium narrow, apical two thirds broadly and roundly expanded. Connexivum not at all prominent, scarcely visible in the male. Bristles dark brown, clavate, forming rows and clumps on the hemelytra, scutellum and pronotum. Abdominal sternites of male asymmetrical; last three sternites small, distance between caudolateral angles of sixth sternite less than half the width of the posterior margin of the fourth sternite. Clasper of male constricted at the middle and then again constricted half way between the middle and the apex, simple and sickle-shaped. Abdominal sternites of the female nearly symmetrical, projecting posteriorly and nearly covering lobes of ovipositor, apex of posterior margin is very slightly emarginate.

Location of type. Unknown. Montandon did not specify which of the specimens before him was the type. The type of this species is not in the British Museum with other Montandon types, at least it was not seen by Doctor H. B. Hungerford in 1928. There are two males in the Paris Museum, "Nouv. Bretagne, LIX—1889" which were before Montandon at the time of the description. These two specimens may be considered as typical until such time as the type, if existant, is located.

Distributional data. Montandon studied specimens from Australia, New Guinea, New Britain and Amboina. This worker has seen only three specimens, all of which are from New Guinea. They are from the following localities: Mt. Hansemann, Astrolabe B., 1901, Biro, 1 female; Lae, June, 1944, F. E. Skinner, 1 male and 1 female, (CAS).

Comparative notes. Most closely related to *Nerthra omani* n. sp. but easily separated by the much wider pronotum and by the fact

that the clasper is twice constricted in this species while in *N. omani* n. sp. this is not the case.

Nerthra omani n. sp.

(Pl. XI, fig. 99)

Size. Male: Length, 9.6 to 10.5 mm.; width of pronotum, 7.2 to 7.6 mm.; width of abdomen, 6.8 to 7.6 mm. Female: Length, 10.6 mm.; width of pronotum, 7.7 mm.; width of abdomen, 7.4 mm.

Color. Light brown to black above, the bristles a little darker; ventrally brown, reddish-brown or black except for some yellow spots on the mid and hind femora and on the pleurites about these legs.

Structural characteristics. Apex of head with five large toothlike tubercles, apical one ventrocaudad of the others; ocelli present. Pronotum widest at transverse furrow, distinctly projecting beyond the base of the embolium, usually slightly wider than abdomen; the median portion of the lateral margins parallel or nearly so, anterior and posterior parts of the margin distinctly converging medially; posterior margins of the pronotum concave before the scutellum then extending in a more or less straight line to the lateral angle. Scutellum moderately large, a tumescence on each side and at the apex. Hemelytra extending to or beyond the end of the abdomen; membrane well developed; base of embolium narrow, apical two thirds broadly and roundly expanded. Connexivum not at all prominent, scarcely visible in the males. Bristles dark brown, clavate, forming rows and clumps on the hemelytra, scutellum and pronotum. Abdominal sternites of male asymmetrical; last three sternites small, distance between caudolateral angles of sixth sternite less than half the width of the posterior margin of the fourth sternite. Clasper of male of nearly equal width for the entire length, but slightly swollen at apical third and then tapering to ovate apex which is recurved. Abdominal sternites of the female nearly symmetrical, projecting posteriorly and nearly covering lobes of ovipositor.

Location of type. Holotype male, allotype female and 2 male paratypes, Guadalcanal, 1944, L. J. Lipovsky, in the Francis Huntington Snow Entomological Collections at the University of Kansas. Three male paratypes, Guadalcanal, June 15, 1942, Paul Oman, in the United States National Museum at Washington, D. C.

Distributional data. Known only from Guadalcanal Island in the Solomon Islands.

Comparative notes. Similar to *Nerthra mixta* (Montandon) but differing in that the pronotum is not nearly so wide in proportion to the width of the abdomen and in that the clasper of the male is nearly of uniform width for the entire length while in the latter species it is strongly constricted at the middle and again half way to the apex.

Nerthra femoralis (Montandon)

(Pl. XII, fig. 105)

1899. *Mononyx femoralis* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, nos. 4 and 5, p. 407.
1902. *M. femoralis* Horvath, Természetrajzi Füzetek, XXV, p. 612.
1925. *M. femoralis* Hale, Arkiv. for Zoologi utgivet av Kongliga Svenska Vetenskapsakademien, Band 17A, No. 20, p. 16.

Size. Male: Length, 7.8 mm.; width of pronotum, 5.7 mm.; width of abdomen, 5.7 mm. Female: Length, 8.8 to 10.0 mm.; width of pronotum, 6.1 to 6.6 mm.; width of abdomen, 6.1 to 6.8 mm.

Color. Yellowish-brown to dark reddish-brown; mostly dark below, trochanters and femora of legs yellow to yellowish-brown suffused with red on the trochanters and basal halves of the femora, femora dark at apices.

Structural characteristics. Front of head with five rather prominent tubercles, four on frons and one at the apex, the latter not visible from a dorsal view. Pronotum widest at middle, slightly projecting beyond base of embolium, about as wide as abdomen; lateral margins more or less rounded, anterior and median portions nearly straight; posterior margin broadly and weakly sinuated before scutellum; posterior third of pronotum crossed by seven indistinct longitudinal carinations. Scutellum not very elevated, a moderate tumescence at each side, mesad of each tumescence a small oval depression. Hemelytra extending beyond end of abdomen in the male, not quite reaching end of abdomen in the female, entirely covering the abdomen laterally in the male, some of abdomen exposed laterally in the females; embolium slightly dilated laterally, lateral margin convex for entire length; hemelytra constricted at nodal suture. Groups and lines of black clavate bristles present on pronotum, scutellum and hemelytra. Mesosternal process apically blunt to moderately pointed, lateral margins nearly straight. Abdominal sternites of female symmetrical; last visible abdominal sternite dilated posteriorly, nearly covering lobes of ovipositor, posterolateral angles slightly and roundly projecting posteriorly. Abdominal sternites of male asymmetrical, last three small; ninth sternite wider than long, slightly longer then eighth

sternite, about twice as long as seventh sternite. Male clasper simple, curved medially, slightly rounded and swollen apically.

Location of type. In the British Museum at London, England.

Distributional data. Montandon's specimens were from Champion Bay, Sidney, Australia. The specimens examined by this writer are all from Western Australia. They are from the following localities:

Bridgeton, Nov. 11, Darlington, 2 females, (MCZH); Pemberton, Nov. 10, W. M. Wheeler, 1 female, (MCZH); Rottnest Isl., Oct. 24, P. J. Darlington, 1 female, (MCZH); Wallcliffe, Margaret R., Oct., Darlington, 1 female, (MCZH); Wongong R., Perth, Jan., W. S. Brooks, 1 male, (MCZH).

Comparative notes. Most closely related to N. *gurneyi* n. sp. but differing in that the clasper of the male is stouter and by the fact that the lateral margin of embolium is not concave basally and that there is a suffusion of red on the trochanters and basal halves of the femora.

It should be pointed out that in the original description Montandon states that the front of the head has only four toothlike tubercles. It is possible that he did not notice the apical tubercle which is not visible from above or that he did not consider it to be on the front of the head, or, this species may only have four tubercles on the head. Hale, 1925, also suggests that *N. femoralis* (Montandon) has five tubercles on the head. A comparison with type and with my drawing of the male clasper of one of the above specimens has been made by Doctor R. L. Usinger. He found them to be nearly identical; however, he indicated a slight difference in the apex of the clasper which may possibly have been due to a difference in the plane in which the clasper was studied. Unfortunately I did not have him check the tubercles of the head. If the type of *N. femoralis* (Montandon) does have but four toothlike tubercles on the head there is the possibility that the specimens herein described are not this species but are *N. annulipes* (Horvath). It will be necessary to check also the genitalia of the type of the latter species if it is a male. Horvath's description would seem to indicate that he had only a single female specimen before him. For the present I prefer to place the specimens studied as *N. femoralis.* The original description of *N. annulipes* (Horvath) will be presented further on in this paper.

Nerthra nudata n. sp.

(Pl. XI, fig. 100)

Size. Male: Length, 9.2 to 9.6 mm.; width of pronotum, 6.0 to 6.1 mm.; width of abdomen, 6.2 to 6.5 mm.

Color. Light brown to black; bases of legs reddish, apices of femora black, rest of legs yellowish-brown; abdominal segments coppery or reddish-brown except last three segments which are brown.

Structural characteristics. Front of head without prominent tubercles, a faint medial tubercle of frons present in one specimen. Pronotum widest at a level of the transverse furrow, barely projecting laterally beyond base of embolium, not quite as wide as abdomen; lateral margin with medial and anterior portions weakly concave; posterior margin slightly sinuated before scutellum; posterior third of pronotum crossed by three broad indistinct longitudinal carinations. Scutellum elevated, tumescences at sides and apex, weakly depressed medially. Hemelytra extending beyond end of abdomen, entirely covering abdomen; embolium elongate, lateral margin smoothly convex; hemelytra hardly constricted at nodal suture. Five patches of short clavate bristles on each hemelytron and a patch on each basal tumescence of the scutellum. Mesosternal process short, lateral margins rather broad and straight, apex very blunt, broadly flattened. Abdominal sternites of male asymmetrical; last three sternites small; ninth sternite rather oval, longer than seventh or eighth sternites, slightly wider than long. Male clasper simple, sickle-shaped; aedeagal furrow visible from a ventral view for a short distance laterally at apex, also for a short distance medially at basal fourth.

Location of type. Holotype male and two male paratypes, Brisbane, Q., Australia, March 3, 1932, P. J. Darlington, in the Museum of Comparative Zoology at Harvard University. One male paratype, McPherson Range, Nat. Park, Q., Australia, March 16, 1932, P. J. Darlington, in the Francis Huntington Snow Entomological Museum at the University of Kansas.

Distributional data. As given for the type series.

Comparative notes. Easily recognized by the absence of tubercles on the front of the head and by the shape of the clasper.

Nerthra annulipes (Horvath)

1902. *Mononyx annulipes* Horvath, Természetrajzi Füzetek, vol. XXV, pp. 611-612.
1902. *M. annulipes* Froggatt, Agricultural Gazette of N. S. Wales, Misc. Publ. no. 538, p. 7, pl. II, fig. 25.
1943. *M. annulipes* McKeown, Australian Museum Magazine, vol. 8, no. 5, pp. 176-180.

The writer has not seen this species, or at least has not been able to recognize it.

Original description: "Beviter ovalis, supra sordide griseus; capite antice quinque-tuberculato; pronoto longitudine sua duplo et dimidio latiore, abdomini aequilato, disco rugis longitudinalibus irregularibus praedito, marginibus lateralibus dilatatis parce subtiliterque nigro-granulatis, subrectis, parallelis, tantum apice subito introsum curvatis; scutello tuberculis tribus nigrogranulatis, duobus subbasalibus majoribus, uno anteapicali minore, instructo; hemelytris apicem abdominis subattingentibus et margines laterales abdominis pone m e d i u m anguste detectos relinquentibus, margine costali sensim arcuato, haud sinuato, corio venis elevatis nigro-granulatis instructo et praesertim prope marginem costalem parce subtiliterque nigro-granulato, membrana rudimentaria, sed distincte valvante, intus fusco-limbato; corpore subtus fusco-nigro, luteo-variegato; ventre minute granulato; tuberculo mesosterni in processum longisculum, antrorsum curvatum producto; pedibus luteis, maculis femorum anticorum, annulis duobus femorum posteriorum et tibiarum intermediarum, tibiis posticis (basi excepta) tarsisque fusco-nigris. " ♀ Segmento ultimo ventrali apice rotundato-truncato, segmenta genitalia tegente, marginibus lateralibus subrectis. Long. 7.75, Lat. 5.25 mill.

"Clarence River.

"By the rudimentary membrane allied to *M. femoralis* Montd., from which it may be separated by the smaller size, the head having five tubercles in front, the mesosternal tubercle curved forward and the dark annulated legs."

The possible relationship of this species to *N. femoralis* (Montandon) has been discussed in the comparative notes of that species.

Nerthra ampliata (Montandon)

(Pl. XII, fig. 111)

1899. *Mononyx ampliatus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, nos. 4 and 5, p. 404.
1906. *M. ampliatus* Distant, Fauna British India, vol. V, p. 313.

Size. Male: Length, 9.5 to 10.4 mm.; width of pronotum, 6.9 to 7.4 mm.; width of abdomen, 6.8 to 7.3 mm. Female: Length,

9.4 to 11.1 mm.; width of pronotum, 6.5 to 7.8 mm.; width of abdomen, 6.6 to 7.8 mm.

Color. Brown above, ventrally mostly dark brown, a small yellowish-brown area near apex of hind femora.

Structural characteristics. Front of head provided with five tubercles, four on frons and one on apex, the latter not visible from above. Pronotum widest at middle, distinctly projecting laterally beyond the base of embolium; lateral margins more or less rounded; posterior margin broadly but shallowly sinuated before scutellum; posterior third of pronotum crossed by three slight and four very faint longitudinal carinations. Scutellum elevated, tumescent at middle of lateral margins and along median line. Hemelytra extending beyond end of abdomen and laterally almost completely covering abdomen; lateral margin of embolium slightly concave at basal half, posterior part dilated; hemelytra constricted at nodal suture. Abdominal sternites of male asymmetrical; ninth sternite more or less oval, as long as eighth sternite, longer than seventh, wider than long. Male clasper swollen at apex, indistinctly lobed laterally, concavely depressed basad of the broadest part of the dilation.

Location of type. In the British Museum at London, England.

Distributional data. This species is known only from New Guinea. This worker has examined specimens from the following localities:

Orazay, Dec., 1945, Helfer, 1 male; Slephansort, Astrolabe Bay, 1900, Biro, 1 female; Aligaba Crk., May 20, 1943, B. E. Rees, 1 female, (USNM); Laloki, Apr., 1909, F. Muir, 2 males and 7 females, (CAS); "N. Guinea," no date, B. P. Clark, 1 female, (USNM); "N. Guinea," no date or collector, 1 female.

Comparative notes. This species is similar to *Nerthra robusta* n. sp. and *Nerthra macrostyla* n. sp., but differing in that it is a little smaller and in the shape of the male genitalia. The clasper of the male is much smaller than that of either of the species mentioned above. It also differs from *N. robusta* n. sp. in that the dilation of the apical half of the clasper is not angulate laterally but is lobed. In *N. macrostyla* n. sp. this portion of the clasper is also lobed, but more distinctly so, and the lobe is constricted at the base while this is not true in the case of *N. ampliata* (Montandon).

Nerthra macrostyla n. sp.

(Pl. XI, fig. 103)

Size. Male: Length, 11.5 mm.; width of pronotum, 7.5 mm.; width of abdomen, 7.5 mm. Female: Length, 11.3 to 11.7 mm.; width of pronotum, 7.2 to 7.6 mm.; width of abdomen, 6.9 to 7.6 mm.

Color. Dark reddish-brown, embolium lighter with distinct, irregular black spots; mostly dark brown below, yellowish-brown area near the apex of the intermediate and hind femora and small yellowish-brown spots at the posterior lateral angles of each abdominal segment.

Structural characteristics. Front of head provided with five rather large sharply pointed tubercles four on frons and one at apex, the latter not visible from a dorsal view. Pronotum widest at middle, distinctly projecting laterally beyond the base of the embolium; lateral margins more or less rounded, median portion nearly straight parallel to longitudinal axis of the body, anterior and posterior portions converging obliquely to the eye and base of embolium respectively; posterior margin sinuated before scutellum; posterior third of pronotum crossed by three slight and six very indistinct longitudinal carinations. Scutellum rather large, elevated, tumescent laterally and along median line. Hemelytra extending beyond end of abdomen, completely covering abdomen laterally; embolium narrow and concave at base dilated behind concavity; hemelytra slightly constricted at nodal suture. Groups of blackish-brown clavate bristles on the pronotum, scutellum and hemelytra. Abdominal sternites of male asymmetrical; ninth sternite wider than long, not as long as eighth sternite but longer than seventh sternite. Male clasper very large, swollen apically, a large lobe on the lateral surface, concavely depressed basad of the lobe.

Location of type. Holotype male and allotype female, Bougainville I., July 1 to Sept. 15, 1944, A. B. Gurney, and 3 female paratypes, Bougainville I., June 5, 1955, A. B. Gurney, in the United States National Museum at Washington, D. C. One female paratype, Treasury I., Solomon Is., Aug. 14, 1944, J. H. Paullus, in the Francis Huntington Snow Entomological Collection at the University of Kansas. One female paratype, Naval Air Base, Bougainville, Solomon Is., Apr. 1945, G. E. Bohart, in the Collection of the California Academy of Science, at San Francisco, California.

Distributional data. As given for the type series. This species appears to be restricted to the Solomon Islands, however, too few

specimens are known to definitely state that this species has such a limited distribution.

Comparative notes. Very closely related to *N. ampliata* (Montandon) and *N. robusta* n. sp., but easily separated in the males by the shape of the clasper. The females are difficult to distinguish from the other species, but seem to be more slender. As the females are so difficult to identify, one must rely upon distributional data, size, and association with the males.

Nerthra robusta n. sp.

(Pl. XI, fig. 102; Pl. XV, fig. 140)

Size. Male: Length, 11.2 to 12.5 mm.; width of pronotum, 7.6 to 8.1 mm.; width of abdomen, 7.6 to 8.0 mm. Female: Length, 11.7 to 12.5 mm.; width of pronotum, 8.3 to 8.4 mm.; width of abdomen, 7.9 to 8.2 mm.

Color. Light brown above, scutellum darker, lateral margin of the embolium with faint yellowish-brown spots; below mostly dark brown, a light spot before the apex of femur of intermediate and hind legs.

Structural characteristics. Front of head provided with five large, rather pointed tubercles, four on frons and one at apex, the latter not visible from a dorsal view. Pronotum widest at the middle, distinctly projecting beyond base of embolium; lateral margins more or less rounded, medial portion sometimes straight, anterior and posterior portions converging obliquely to the eye and base of embolium respectively; posterior margin broadly sinuated before scutellum; posterior third of pronotum crossed by seven indistinct longitudinal carinations. Scutellum elevated, tumescent laterally and along median line. Hemelytra extending to or beyond end of abdomen, laterally in the male completely covering abdomen; embolium narrow at base, lateral margin at base distinctly concave, dilated laterally on apical half; hemelytra slightly constricted at nodal suture. Groups of black clavate bristles on the pronotum, scutellum and hemelytra. Mesosternal process apically moderately pointed, lateral margins nearly straight, slightly rounded at apex of process. Abdominal sternites of male asymmetrical; ninth sternite wider than long, about same length as eighth sternite, longer than seventh sternite. Male clasper greatly swollen apically, lateral margin of dilation forming almost a right angle at widest point.

Location of type. Holotype male, allotype female, 3 male and 2 female paratypes, Nadzab, Markham R. val., New Guinea, June,

1944, K. V. Krombein in the United States National Museum at Washington, D. C. One male paratype, same data as above and one female paratype, same place, July, 1944, same collector, in the Francis Huntington Snow Entomological Collections at the University of Kansas.

Distributional data. As given above for the type series.

Comparative notes. Near *Nerthra ampliata* (Montandon) and *Nerthra macrostyla* n. sp., but differing from these in that the dilation of the apical half of the clasper of the male is distinctly angulate laterally while in the two species mentioned above the lateral margin of the dilation is more or less lobed.

Nerthra luteovaria (Distant)

(Pl. XII, fig. 107; Pl. XV, fig. 136)

1904. *Mononyx luteovarius* Distant, Annals and Magazine of Natural History, ser. 7, vol. XIV, p. 63.
1925. *M. luteovarius* Hale, Arkiv. for Zoologi utgivet av Kongliga Svenska Vetenskaps-Akademien, Band 17a, No. 20, p. 15.

Size. Male: Length, 7.8 mm.; width of pronotum, 5.7 mm.; width of abdomen, 5.5 mm. Female: Length, 7.8 to 8.5 mm.; width of pronotum, 6.0 to 6.4 mm.; width of abdomen, 5.8 to 6.0 mm.

Color. Uniformly bright yellowish-brown above; below mostly yellowish-brown, tarsal claws dark shiny brown, abdomen, basally and medially, brown.

Structural characteristics. Five sharp-pointed tubercles on front of head, four on frons and one on the apex of the head, the latter not visible from above. Pronotum widest at the middle, distinctly projecting beyond base of embolium, slightly wider than abdomen; lateral margins more or less rounded, anterior portion very slightly concave; posterior margin sinuated before scutellum; posterior third of pronotum crossed by two moderate and three indistinct longitudinal carinations. Scutellum elevated, a tumescence at each side. Hemelytra extending posteriorly beyond end of abdomen, nearly entirely covering abdomen in male, connexivum more apparent in female; embolium slightly dilated, lateral margin more or less rounded, very slightly concave at basal third. Mesosternal process with lateral margins more or less rounded, apex blunt. Abdominal sternites of the female symmetrical, last visible abdominal sternite broadly expanded posteriorly, covering lobes of ovipositor. Abdominal sternites of the male asymmetrical, ninth sternite about as long as eighth, wider than long. Male clasper short and broad, apex distinctly narrowed and bent laterally.

Location of type. In the British Museum at London, England.

Distributional data. The specimens examined by the writer were from Kinberley, Dist., N. V., Australia, Jan., Mjoberg, 1 male and 2 females.

Comparative notes. A small species, characterized by the shape of the mesosternal process and the clasper of the male.

Nerthra tuberculata (Montandon)

(Pl. XII, fig. 104; Pl. XV, fig. 137)

1899. *Mononyx tuberculatus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, An. VIII, Nos. 4 and 5, p. 403.

Size. Male: Length, 8.5 to 8.9 mm.; width of pronotum, 6.1 to 6.4 mm.; width of abdomen, 6.0 to 6.3 mm. Female: Length, 9.2 to 9.9 mm.; width of pronotum, and abdomen, 6.5 to 7.0 mm.

Color. Black, covered with minute white granules which give the insect a gray appearance; front of head with white tubercles forming an inverted V; anterior edge of front trochantur and femur whitish-yellow; apex of femur, tibia and tarsus of intermediate and hind legs yellowish-brown; rest of ventral surface dark brown to black.

Structural characteristics. Front of head with five large, sharply pointed tubercles, four on the frons and one on the apex, the latter not visible from a dorsal view. Pronotum projecting beyond base of embolium, about as wide as abdomen; lateral margin more or less rounded; transverse furrow crossed by two prominent longitudinal carinations; posterior margin deeply sinuated before scutellum. Scutellum elevated, tumescent laterally and at apex. Hemelytra extending beyond end of abdomen, overlapping in such a manner as to give the posterior end of the body a pointed effect; embolium narrow at base, quite wide at nodal suture, lateral margin nearly straight, rounded posteriorly; hemelytra distinctly constricted at nodal suture. Abdomen almost entirely covered by the hemelytra. Body covered with dark shiny reddish-black globoid tubercles. Mesosternal process with lateral margins more or less straight, apex moderately blunt. Abdominal sternites of male asymmetrical; last three sternites narrow; ninth about same length as eighth, longer than seventh, wider than long. Male clasper swollen ventrally near apex; in ventral view, lateral and mesal margins wedge-shaped apically.

Location of type. In the Museum of Brussels, Brussels, Belgium.

Distributional data. The type was from Port Denison, Australia. The writer has seen specimens from the following localities:

Southwestern Australia: Margaret R., Oct. 31, P. J. Darlington, 2 males and 2 females, (MCZH).

Western Australia: Pemberton, W. A., Nov. 10, P. J. Darlington, 1 male, (MCZH); Worgong R., Perth, W. Austr., Jan., W. S. Brooks, 1 female, (MCZH).

Comparative notes. The white tubercles on the front of the head, shiny reddish-black globoid tubercles on the body, hemelytra pointedly projecting posteriorly and the male clasper distinguish this species from others.

Nerthra alaticollis (Stål)

(Pl. XII, fig. 114; Pl. XIII, fig. 118; Pl. XIV, fig. 127)

1854. *Mononyx alaticollis* Stål, Ofversigt af Kongl. Vetenskaps-Akademiens Forhandlingar, arg. 11, p. 239.
1859. *M. alaticollis* Dohrn, Catalogus Hemipterorum, Herausgegeben von dem Entomologischen Verein zu Stettin, p. 54.
1861. *Matinus alaticollis* (Stål); Stål, Ofversigt af Kongl. Vetenskaps-Akademiens Forhandlingar, arg. 18, p. 201.
1863. *M. alaticollis* Stål, Berliner Entomologische Zeitschrift, VII, p. 407.
1876. *M. alaticollis* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, No. 4, p. 139.
1900. *M. alaticollis* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, no. 6, pp. 4-5.
1906. *M. alaticollis* Kirkaldy, Trans. Am. Ent. Soc., vol. XXXII, p. 149.

Size. Male: Length, 6.7 to 7.3 mm., width of pronotum, 5.0 to 5.5 mm., width of abdomen, 5.0 to 5.6 mm. Female: Length, 7.4 to 8.5 mm., width of pronotum, 5.5 to 6.4 mm., width of abdomen, 5.2 to 6.3 mm.

Color. Quite variable, but in general, grey to light brown in over-all appearance. Ground color runs from light yellow to black. Disc of pronotum, scutellum, and head usually darker than rest of body; in some these parts are black while the hemelytra and lateral expansions of the pronotum are light yellow. Front of head may have apical half orange or white or may be entirely black. Anterior margin of front femora, bases and apices of middle and hind femora may be almost white. The ventral abdominal segments generally dark reddish-brown with the spiracles and area immediately surrounding the spiracles lighter. The lateral margins of the embolium and the pronotum with alternating dark brown and yellow spots in most specimens.

Structural characteristics. Head with five rather small, sharp-pointed tubercles, apical tubercle not visible from above; front rather flat; ocelli present. Pronotum widest at the middle; lateral margin

more or less rounded, median half nearly straight in some specimens; disc elevated and pitted with many small, irregular depressions; posterior margin trisinuate. Scutellum slightly elevated; small to moderate lateral tubercle at middle of each side, a small pitlike depression postero-mesad of these; apex may or may not be elevated. Hemelytra usually extending to or beyond end of abdomen; bluntly pointed apically; membrane absent, hemelytra entirely coriaceous, not fused; embolium extremely expanded apically. Connexivum variable in degree of expansion, broadly expanded in some, not so much so in others. Hemelytra and scutellum nearly glabrous, lacking black, clavate bristles. Abdominal sternites of female nearly symmetrical; projecting posteriorly and almost completely covering the lobes of ovipositor; posterior margin of last visible sternite projecting posteriorly laterad of apex which is slightly concave. Abdominal sternites of male with last three segments small, less than one-half the width of the posterior margin of the fourth sternite; ninth sternite oval, slightly wider than long, longer than eighth sternite; eighth longer than seventh. Clasper of male sickle-shaped, slightly swollen basally, apex slender, slightly recurved.

Location of type. In the Museum of Stockholm, Stockholm, Sweden.

Distributional data. This species is known only from Australia. The writer has seen specimens from the following localities:

Brisbane, June 11, 1915, Bridwell, 1 male and 1 female, (USNM); same place, no date, H. Hacker, 1 female; Caloundra, Oct. 10, 1912, no collector, 1 female; Leura, N. S. Wales, no date, W. M. Mann, 1 female, (MCZH); Megalong Vy., Blue Mts., N. S. Wales, Jan. 20, 1932, Darlington, 1 female, (MCZH); Moreton Bay, Stradbrokel, Queensland, Sept. 20, 1915, J. C. Bridwell, 1 female, (USNM); N. S. Wales, no date, Hy. Edwards Collection, 1 female; same place, no date, same collector, 1 female, (AMNH); Weathcote, N. S. Wales, Dec. 7, 1914, C. T. Brues, 1 female, (MCZH); Wentworth Falls, N. S. Wales, Dec. 29, 1931, W. M. Wheeler, 1 male, (MCZH).

Comparative notes. This species is most closely related to *Nerthra adspera* (Stål) and *N. stali* (Montandon). It may be separated from both by the shape of the lateral margin of the pronotum.

Nerthra adspersa (Stål)

(Pl. XIII, fig. 122)

1863. *Matinus adspersus* Stål, Berliner Entomologische Zeitschrift, VII, p. 407.
1876. *M. adspersus* Stål, Kongl. Svenska Vetenskaps-Akademiens Handlingar, Band 14, No. 4, p. 139.
1900. *M. adspersus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, An. VIII, no. 6, p. 5.

Size. Length, 6.0 mm., width of pronotum, 5.2 mm., width of abdomen, 5.2 mm. This specimen has had the posterior portion of abdomen eaten by dermestids, and this makes the determination of sex impossible, in view of present knowledge.

Color. Pale reddish-brown, almost pink. Scutellum and maculations on margins of hemelytra and pronotum darker, the former with a reddish cast, the latter brown. Lateral tubercles and apex of head nearly white. Below, with abdominal segments dark brown with large light yellow areas along the lateral margin of each segment. Front femora dark reddish-brown, tibiae lighter.

Structural characteristics. Head lacking sharp-pointed tubercles, a large blunt tubercle on the lateral margin immediately below the inner margin of the eye; front quite flat; vertex nearly transverse, scarcely convex; apex of head depressed, base of depression wider than distance between ocelli. Pronotum greatly expanded laterally, widest at a point just anterior of the humeral angle; lateral margin with posterior two-thirds subparallel, gradually converging anteriorly, anterior one third abruptly converging toward the eye; posterior margin trisinuate. Scutellum weakly elevated, lacking prominent elevations; a shallow depression present at the middle on either side of the median line. Hemelytra very broad, completely covering abdomen, membrane apparently lacking, but as this portion is slightly damaged also it is not possible to say definitely; embolium greatly expanded laterally.

Location of type. In the Museum of Stockholm, Stockholm, Sweden.

Distributional data. Stål described this species from specimens from Western Australia. The specimen studied by this worker is also from Western Australia, Kirkaldy Collection, which is now owned by the University of Kansas.

Comparative notes. This species is closely related to *N. alaticollis* (Stål) and *N. stali* (Montandon). It can be separated from the former by the shape of the pronotum and from the latter by the large lateral tubercles of the head and by the fact that the base

of the depression of the apex of the head is wider than the distance between ocelli. Montandon examined one of the types and mentions that the tubercles of the head are quite visible, especially the lateral tubercles which are located below each eye. The length of the type was also slightly smaller than the specimen before the writer, measuring 5.5 mm.

Nerthra stali (Montandon)

(Pl. XIII, fig. 125; Pl. XIV, fig. 133)

1900. *Matinus stali* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, An. VIII, No. 6, pp. 5-6.

Size. Female: Length, 7.7 to 8.1 mm., width of pronotum, 6.8 to 7.0 mm., width of abdomen 6.9 to 7.3 mm.*

Color. Superficially appearing greyish-brown, ground color actually yellowish-brown and this is maculated with reddish-brown; head, disc of pronotum and connexivum slightly darker than rest of dorsum. Below; abdomen dark reddish-brown, except caudolateral portions of each segment which are yellow or yellowish-brown; legs brown with the trochanters, bases and apices of femora, and bases of tibiae, yellow.

Structural characteristics. Head with five small tooth-like tubercles, apical one is ventrad and caudad of the others which are on anterior margins of head; front of head rather flat; ocelli present. Pronotum broadly expanded laterally; disk elevated, pitted; lateral margins of pronotum nearly straight for posterior two thirds, but converging anteriorly, anterior third more abruptly converging toward the eye; posterior angle projecting beyond the base of the embolium, nearly forming a right angle; posterior margin of pronotum almost straight, very slightly concave before scutellum and a small projection even with the base of the claval suture. Scutellum slightly elevated, especially near the middle of the lateral margins and at the apex. Hemelytra entirely coriaceous, not fused together, tapering apically to a blunt point, not quite extending to the end of the abdomen; embolium rather expanded laterad for its entire length. Connexivum broadly expanded, widest part of insect, but only slightly wider than hemelytra and pronotum. Abdominal sternites of female symmetrical; last visible abdominal sternite projecting posteriorly, nearly covering lobes of ovipositor, not emarginate.

* A male has subsequently been examined by the writer. Since he was unable to include an illustration of the genetalia in this paper, the specimen will be discussed in a separate paper.

Location of type. In the Museum of Stockholm, Stockholm, Sweden.

Distributional data. Montandon described this species from a female specimen from occidental Australia. The worker has studied the following specimens also from Western Australia:

Augusta, Febr., W. S. Brooks, 2 females, (MCZH); "Austral. occident.," no date or collector, 1 female, (Museum of Stockholm).

Comparative notes. This species is most closely related to *N. adspersus* (Stål) and *N. alaticollis* (Stål). It may be separated from the former by the number and type of tooth-like tubercles on the head, by the pitting of the discs of the pronotum and by the shape of the base of the depression of the apex of the head. From the latter it may be separated by the shape of the lateral margin of the pronotum.

Nerthra elongata (Montandon)

1900. *Matinus elongatus* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, An. VIII, No. 6, p. 7.

The writer has not seen any specimens which agree with Montandon's description of this species. Original description:

"Forme allongée, teinte brunâtre obscure assez uniforme sur tout le corps. Tête ruguleuse, subarrondie en avant, sans tubercules dentiformes apparents ni sur le bord externe, ni sur la surface.

Pronotum à cotés latéraux peu dilatés, subparallèles sur les deux tiers postérieurs, assez largement arrondis antérieurement, l'angle postérieur étroitement arrondi, bord postérieur presque droit, très obtusément subsinué devant l'écusson et très faiblement obliqué latéralement de chaque coté. Rides et sillons du pronotum peu accentués, très obtus.

Ecusson à peine un peu plus long que large.

Elytres très obtusément arrondies au bord externe, sans aucune sinuosité sur la marge, recouvrant entièrement le connexivum et dépassant faiblement l'extrémité de l'abdomen; membrane à peu près nulle, presque indistincte, à peine valvante.

Dessous du corps assez uniformément brunâtre, plus clair sur la poitrine près des hanches. Pattes brunâtres, plus claires avec trois grandes taches flaves mal limitées sur la partie inférieure des fémurs intermédiaires et postérieurs, la partie supérieure de ces fémurs regardant le corps au repos, presque entièrement flave. Les fémurs antérieurs assez dilatés, bruns en dessous, presque entièrement flaves à leur partie supérieure.

Tubercule du mesosternum pas très élevé, étroit dès la base et obtus au sommet.

Dernier segment de l'abdomen ♀ largement tronqué à l'extrémité, laissant apercevoir une très faible portion des pièces génitales. Avant dernier segment abdominal non ou imperceptiblement ré tréci au milieu Australie (Fischer 1878) exemplaire unique. K. K. Hof Museum Vienne."

Nerthra tasmaniensis n. sp.

(Pl. XV, fig. 143)

Size. Male: Length, 6.3 mm.; width of pronotum, 4.4 mm.; width of abdomen, 4.4 mm.

Color: Light brown above covered with many white granulations. The white granules combine with white pigment to form some fairly large patches of white on the hemelytra. Connexivum with the basal halves of the segments dark brown and the apical halves orangish-brown. Apical half of the head much lighter than the basal portion, the extreme apex is a very pale yellow. On the underside the body is dark brown except for a small yellow spot at the posterocaudal angles of each abdominal segment. Basal segments of forelegs pale yellow to just before apex of femora, dorsal surface of femora tinged with pink and the apex reddish-brown; tibio-tarsi are reddish-brown and the tarsal claw is black. Intermediate and hind legs with the basal half of the femora dull brown followed by a pale yellow area and with a reddish apex; tibiae, tarsi and tarsal claws reddish-brown.

Structural characteristics. Apex of head depressed, width of base of depression less than distance between ocelli; head with five small toothlike tubercles, apical one is ventrad and caudad of the others which are on the anterior margins of head; front of head rather flat; ocelli present, but very small. Pronotum broadly expanded laterally; disk elevated, pitted; lateral margins of pronotum with anterior two fifths straight, strongly converging toward the eyes, posterior two fifths with the two sides subparallel, slightly convergent anteriorly, slightly concave; humeral angle rounded; posterior margin nearly straight, very slightly convex; pronotum widest level with the transverse furrow, but only slightly exceeding in width the body at the base of the embolia. Scutellum apparently not noticeably elevated, but it is very badly damaged by the pin and accurate description is not possible. Hemelytra extending to end of abdomen, entirely coriaceous, membrane absent, not fused; embolia greatly expanded basally, lateral margins nearly straight; edge of hemelytra con-

stricted at embolial suture. Connexivum barely visible, parts of but two segments appearing from above. The last three ventral abdominal sternites of the male small, less than one-half the width of the posterior margin of the fourth sternite; ninth sternite oval, slightly wider than long, longer than eighth sternite; eighth longer than seventh. Clasper (apical half) simple, tapering rapidly to rather slender apex, very slightly sickle-shaped nearly straight.

Location of type. Unique, holotype male, L. St. Clair Res., Tasmania, October, 1939, D. M. in the British Museum, London, England.

Distributional data. As given for the type.

Comparative notes. This species is very closely related to *N. alaticollis* (Stål). The clasper of the male is very similar to the clasper of the above-mentioned species. The pronotum is quite different and the specimen is from a locality from which I have seen no other material. It may be that further material from Tasmania will show that the specimen before the writer is abberant, but until such time as more specimens are available, the pronotal differences seem sufficient for specific designation.

Nerthra suberosa (Erichson)

1842. *Mononyx suberosus* Erichson, Archiv für Naturgeschichte, 8, p. 285.

It is possible that this is the species previously described as *Nerthra tasmaniensis* n. sp. since both specimens were from Tasmania. The description does not agree with latter species in respect to size ($3\frac{2}{3}$ lin. is equal to 7.8 mm.) or in regard to the shape of the pronotum. Since the writer has been unable to recognize this species, the original description is given at this point.

"*Mononyx suberosus:* Fuscus, fronte fossulata, thorace basi subtrisinuato, angulis posterioribus obtusiusculis.—Long. $3\frac{2}{3}$ lin."

"Fuscus, opacus. Caput scrobiculatum, griseo-squamulosum. Thorax abdomine paulo latior, lateribus anterius rotundatis, leniter transversim bisulcatus, sulcis inter latera depressa et discum subelevatum foveolatis, dorso postice obsolete tricarinato; fusco-squamulosus. Scutellum basi utrinque carinatum, carinis nigrohirtis. Hemelytra nervis elevatis, fusco-squamulosa, utroque medio lituris tribus minutis nigrohirtis. Corpus infra cum pedibus fuscum, unicolor."

Nerthra walkeri n. sp.

(Pl. XV, fig. 142)

Size. Male: Length, 9.3 mm.; width of pronotum, 7.4 mm.; width of abdomen, 7.3 mm. Female: Length, 9.4 to 9.7 mm.; width of pronotum, 7.3 to 7.6 mm.; width of abdomen, 7.3 to 7.5 mm.

Color. Nearly concolorous, brown, rather dense, black bristles making the specimens appear somewhat darker than they actually are.

Structural characteristics. In general appearance strongly resembling *Nerthra macrothorax* (Montrouzier). Front of head provided with five large, conical tooth-like tubercles, one apical, two marginal and two superapical tubercles. Ocelli present. Width of pronotum equal to or slightly greater than width of abdomen, widest at a level with the transverse furrow; disc slightly elevated; lateral margins subparallel for most part, abruptly converging toward eyes anteriorly, posterior portions of lateral margins slightly convergent from level with transverse furrow toward bases of embolia; posterior margin of pronotum nearly straight, broadly but very shallowly sinuate. Scutellum somewhat depressed basally; clumps of bristles at middle of each lateral margin. Hemelytra extending beyond end of abdomen; entirely coriaceous and fused together; embolia greatly expanded laterally at the base. Connexivum moderate. Body, especially scutellum and hemelytra covered with rather dense clumps of short, clavate bristles. Abdominal sternites of male, small, asymmetrical. Abdominal sternites of female nearly symmetrical; last visible sternite projecting posteriorly and covering the lobes of the ovipositor. Clasper of male stout, slightly recurved and slightly swollen apically.

Location of type. Holotype male, allotype female and 2 female paratypes, Adelaide R., N. W. Australia, J. J. Walker in the British Museum, London, England. One female paratype, same data, in the Francis Huntington Snow Entomological Collection at the University of Kansas, Lawrence, Kansas.

Distributional data. As given for the type series.

Comparative notes. This species appears to be most closely related to *N. grandis* (Montandon) and *N. femoralis* (Montandon), but differs from those two species in the shape of the pronotum, fused hemelytra and in the slightly differently shaped clasper of the male. The presence of ocelli and the toothlike tubercles on the head will distinguish this species from *N. macrothorax* (Montrouzier) which it resembles superficially.

Nerthra sinuosa n. sp.

(Pl. XIV, figs. 131, 134)

Size. Female: Length, 7.5 to 7.8 mm., width of pronotum, 4.8 to 5.2 mm., width of abdomen, 5.0 to 5.4 mm.

Color. Light brown or yellowish-brown, darker on disc of pronotum, base of scutellum and scattered areas on the ventral abdominal segments.

Structural characteristics. Head with four fairly small, marginal toothlike tubercles; ocelli present. Pronotum widest at a point level with the transverse furrow, but only slightly wider than angle at anterior one-fourth of lateral margin, lateral margin between these two points strongly concave; antero- and posterolateral margins slightly concave, converging mesad; posterior margin trisinuate. Scutellum rather flat, a moderately large tumescence on each side at middle of margin, apex slightly elevated. Hemelytra rather pointed apically; membrane reduced to a narrow strip extending from apex along inner margin toward scutellum; extending beyond the end of the abdomen; embolium not very expanded. Connexivum completely covered by hemelytra. Abdominal sternites of female more or less symmetrical, last visible sternite with the apex produced, almost completely hiding lobes of the ovipositor, rather broadly keeled, extreme apex very faintly emarginate.

Location of type. Holotype female, Dorrigo, N. S. Wales, Australia, no date, W. Heron in the Museum of Comparative Zoology at Harvard University. One female paratype, same data, in the Francis Huntington Snow Entomological Collection at the University of Kansas.

Distributional data. As given for the type series.

Comparative notes. This species seems to be close to *N. laticollis* (Guérin-Méneville) on the basis of the lateral margin of the pronotum, but it has the membrane of the hemelytra reduced and is somewhat lighter in color than the latter species.

Nerthra grandis (Montandon)

(Pl. XII, fig. 106; Pl. XIII, figs. 123, 126; Pl. XIV, fig. 129)

1900. *Matinus grandis* Montandon, Bulletin de la Société des Sciences de Bucarest-Roumanie, an. VIII, no. 6, pp. 6-7.

Size. Male: Length, 9.1 mm., width of pronotum, 6.5 mm., width of abdomen, 6.7 mm. Female: Length, 9.0 mm., width of pronotum 6.4 mm., width of abdomen, 6.7 mm.

Color. Almost uniformly dark reddish-brown, nearly black.

Structural characteristics. Front of head with five rather large toothlike tubercles, apical one ventrad and caudad of the others which are on the anterior margin of the head when viewed from above; ocelli present, but very small. Pronotum slightly less in width than abdomen; lateral margin with the posterior three fifths slightly convex, nearly straight, anterior two fifths converging toward the eye, straight; posterior margin trisinuate; transverse suture of disc crossed by three distinct longitudinal carinae. Scutellum depressed at the median basal portion, elevated at the apex and at the middle of each lateral margin, the three elevations connecting to one another. Hemelytra entirely coriaceous with the veins slightly elevated, extending as far as end of abdomen; embolium expanded laterally for its entire length. Connexivum visible in both sexes, rather expanded laterad. Body covered black, clavate bristles which occur in clumps on the hemelytra, the scutellum and the pronotum. Abdominal sternites of the female symmetrical; last visible sternite projecting posteriorly, covering the ovipositor lobes. Last three abdominal sternites of male small, last sternite about two times as wide as long, about equal in length to the eighth sternite and one and one-half times as long as the seventh, ninth sternite only about one-fifth as wide as fourth segment. Clasper of the male simple, sickle-shaped, rather wide at base and tapering gradually to apex which is recurved.

Location of type. In the Museum of Paris, Paris, France.

Distributional data. The specimens Montandon described were from Australia. The writer has examined a pair of this species labeled, Victoria, no date, P. R. Uhler Colln., (USNM).

Comparative notes. The above specimens were determined by Montandon as this species in 1909. It is most closely related to *N. femoralis* (Montandon), but may be distinguished from that species by the entirely coriaceous hemelytra, by the absence of red on the anterior femora and by the shape of the clasper of the male. Montandon's description states that the membrane is reduced, but the two specimens examined by this worker had the hemelytra entirely coriaceous.

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(Italics indicate synonyms.)

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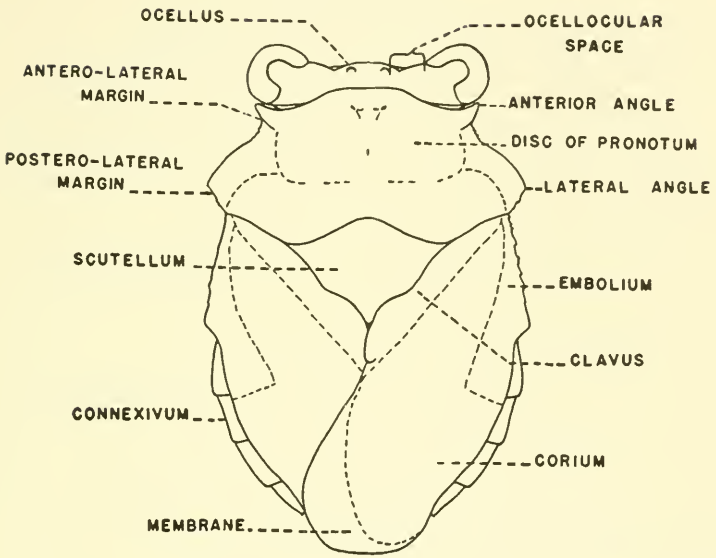
PLATE I

FIG. 1. *G. oculatus* (Fabricius). Dorsal view.
FIG. 2. *G. oculatus* (Fabricius). Ventral view.

PLATE I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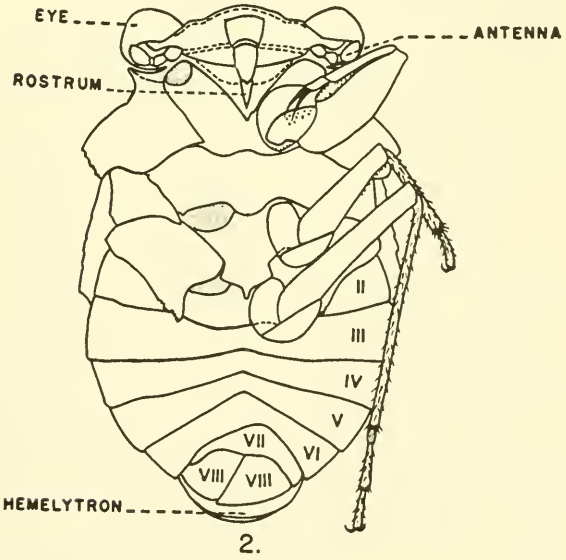
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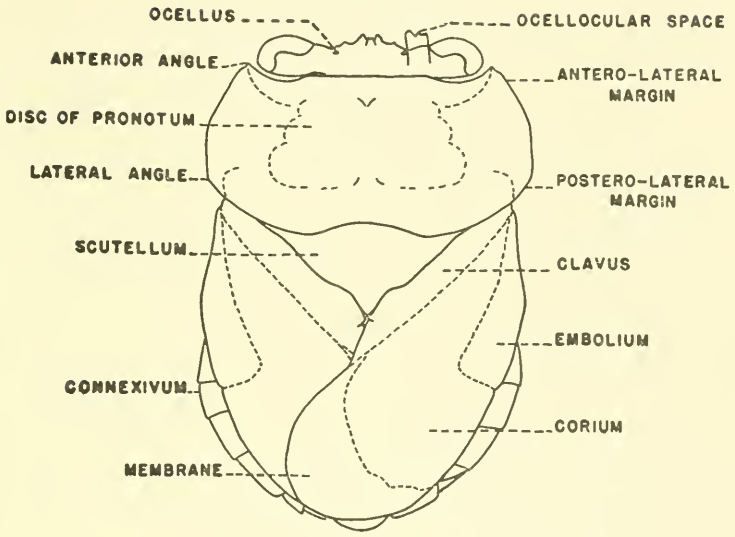
PLATE 2

FIG. 3. *N. ranina* (Herrich-Schäffer). Dorsal view.
FIG. 4. *N. ranina* (Herrich-Schäffer). Ventral view.

PLATE II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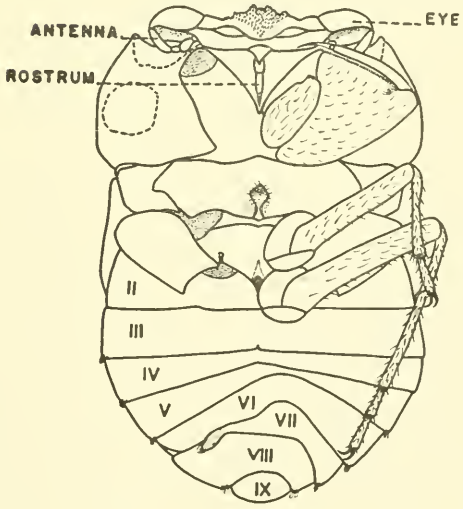
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4

PLATE III

FIG. 5. *G. oculatus* (Fabricius). Antenna.
FIG. 6. *N. ranina* (Herrich-Schäffer). Antenna.
FIG. 7. *N. raptoria* (Fabricius). Portion of foreleg.
FIG. 8. *G. oculatus* (Fabricius). Foreleg.
FIG. 9. *N. ranina* (Herrich-Schäffer). Foreleg.
FIG. 10. *N. buenoi* n. sp. Portion of foreleg.

PLATE III

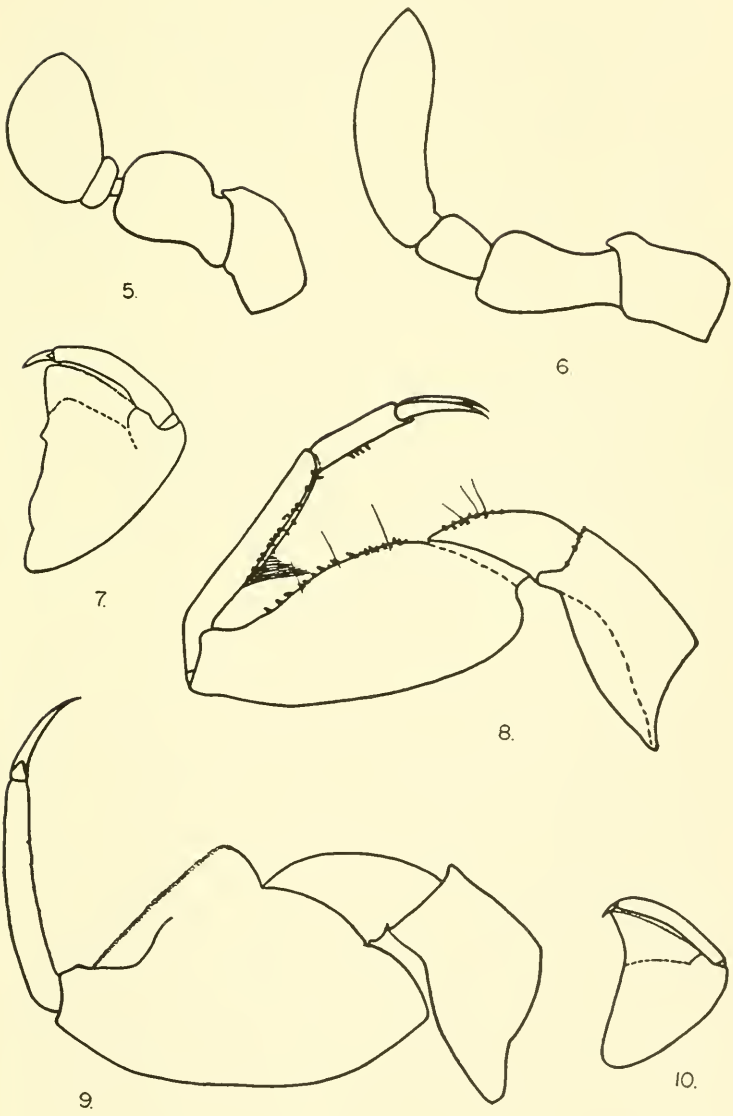
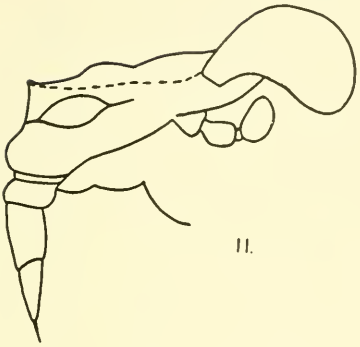


PLATE IV

FIG. 11. *G. oculatus* (Fabricius). Lateral view of head.
FIG. 12. *N. ranina* (Herrich-Schäffer). Lateral view of head.
FIG. 13. *G. viridis* n. sp. Abdominal sternites of male.
FIG. 14. *G. angulatus* (Melin). Abdominal sternites of male.
FIG. 15. *G. bufo* (Herrich-Schäffer). Pronotum.
FIG. 16. *G. oculatus variegatus* (Guérin-Méneville). Pronotum.
FIG. 17. *G. vicinus* Champion. Pronotum.
FIG. 18. *G. rotundatus* Champion. Pronotum.

PLATE IV



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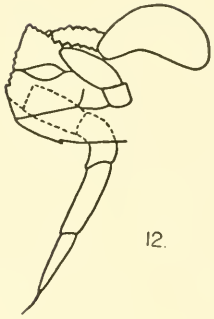

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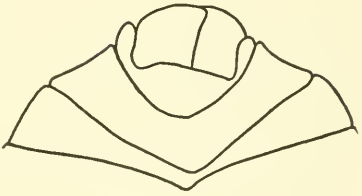

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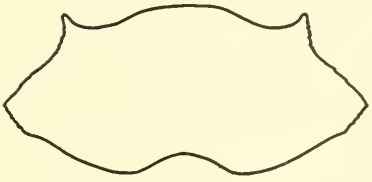

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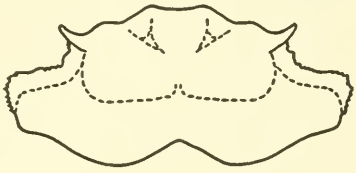

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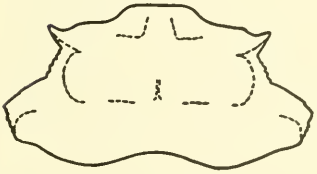

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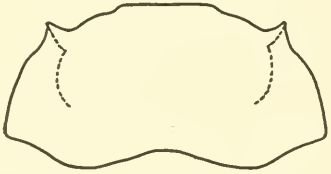
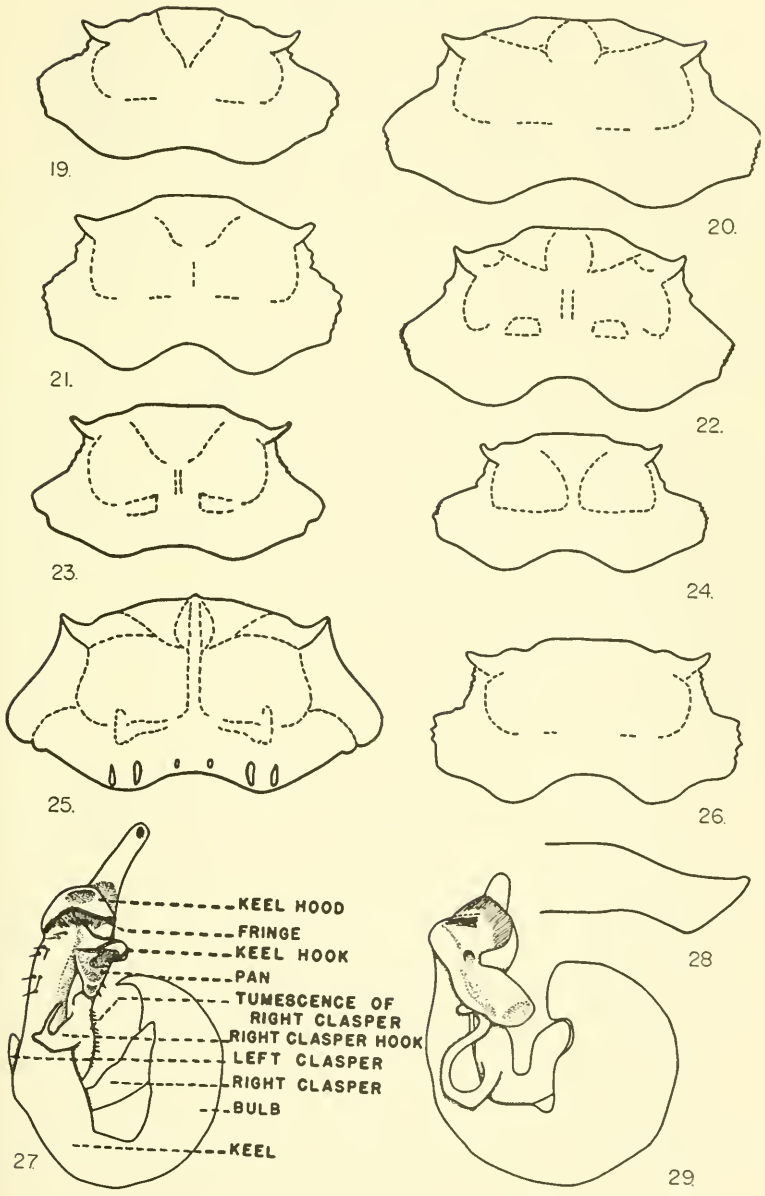


18.

PLATE V

FIG. 19. *G. hungerfordi* Melin. Pronotum.
FIG. 20. *G. fuscus* Martin. Pronotum.
FIG. 21. *G. major* Montandon. Pronotum.
FIG. 22. *G. amazonensis* Melin. Pronotum.
FIG. 23. *G. viridis* n. sp. Pronotum.
FIG. 24. *G. nebulosus* (Guérin-Méneville). Pronotum.
FIG. 25. *G. angulatus* (Melin). Pronotum.
FIG. 26. *G. peruensis* Melin. Pronotum.
FIG. 27. *G. oculatus* (Fabricius). Male genitalia.
FIG. 28. *G. oculatus* (Fabricius). Left clasper of male genitalia.
FIG. 29. *G. angulatus* (Melin). Male genitalia.

PLATE V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23.
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26.
KEEL HOOD
FRINGE
KEEL HOOK
PAN
TUMESCENCE OF RIGHT CLASPER
RIGHT CLASPER HOOK
LEFT CLASPER
RIGHT CLASPER
BULB
KEEL
27
28
29

PLATE VI

Keel and Right Clasper of Male Genitalia.

FIG. 30. *G. rotundatus* Champion.
FIG. 31 *G. oculatus variegatus* (Guérin-Méneville).
FIG. 32. *G. vicinus* Champion.
FIG. 33. *G. hungerfordi* Melin.
FIG. 34. *G. bufo* (Herrich-Schäffer).
FIG. 35. *G. nebulosus* (Guérin-Méneville).
FIG. 36. *G. amazonensis* Melin.
FIG. 37. *G. viridis* n. sp.
FIG. 38. *G. peruensis* Melin.
FIG. 39. *G. major* Montandon.
FIG. 40. *G. fuscus* Martin.

PLATE VI

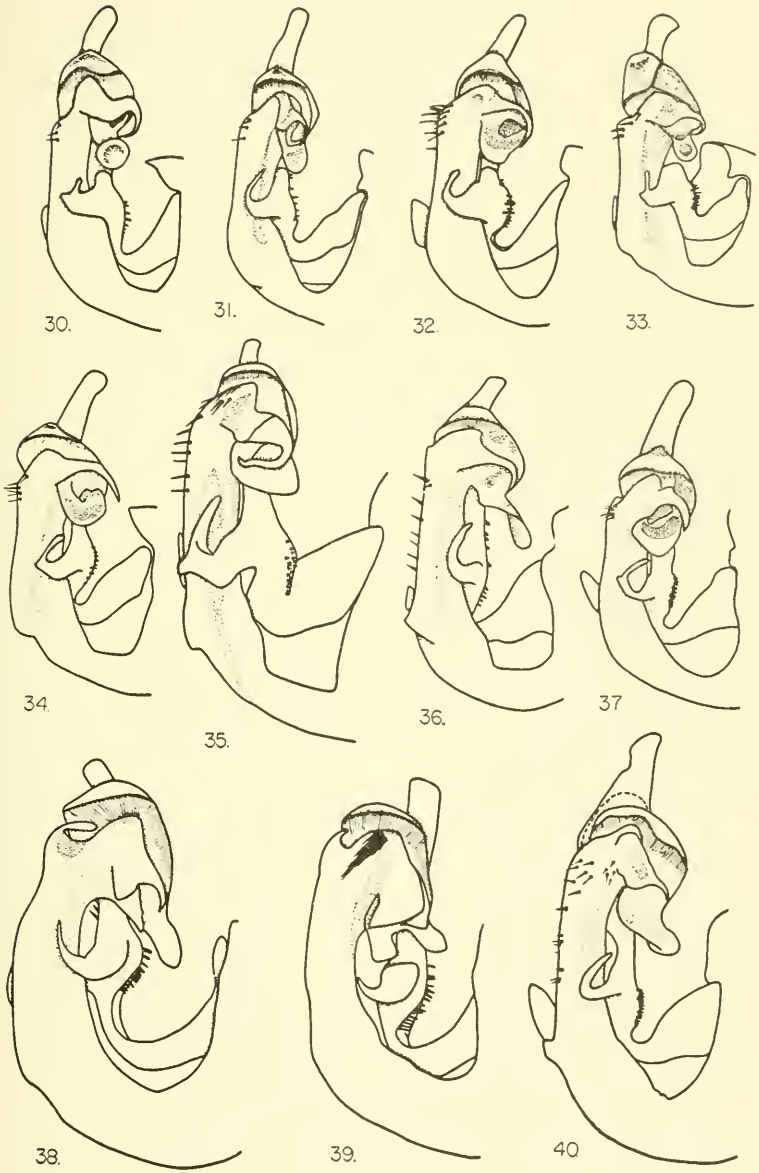


PLATE VII

Right Clasper of Male Genitalia.

FIG. 41. *N. ranina* (Herrich-Schäffer).
FIG. 42. *N. martini* Todd.
FIG. 43. *N. mexicana* (Melin).
FIG. 44. *N. parvula* (Signoret).
FIG. 45. *N. bracchialis* n. sp.
FIG. 46. *N. raptoria* (Fabricius).
FIG. 47. *N. peruviana* (Montandon).
FIG. 48. *N. terrestris* (Kevan).
FIG. 49. *N. nepaeformis* (Fabricius).
FIG. 50. *N. tenebrosa* n. n.
FIG. 51. *N. hungerfordi* n. sp.
FIG. 52. *N. fuscipes* (Guérin-Méneville).
FIG. 53. *N. amplicollis* (Stål).
FIG. 54. *N. manni* n. sp.

PLATE VII

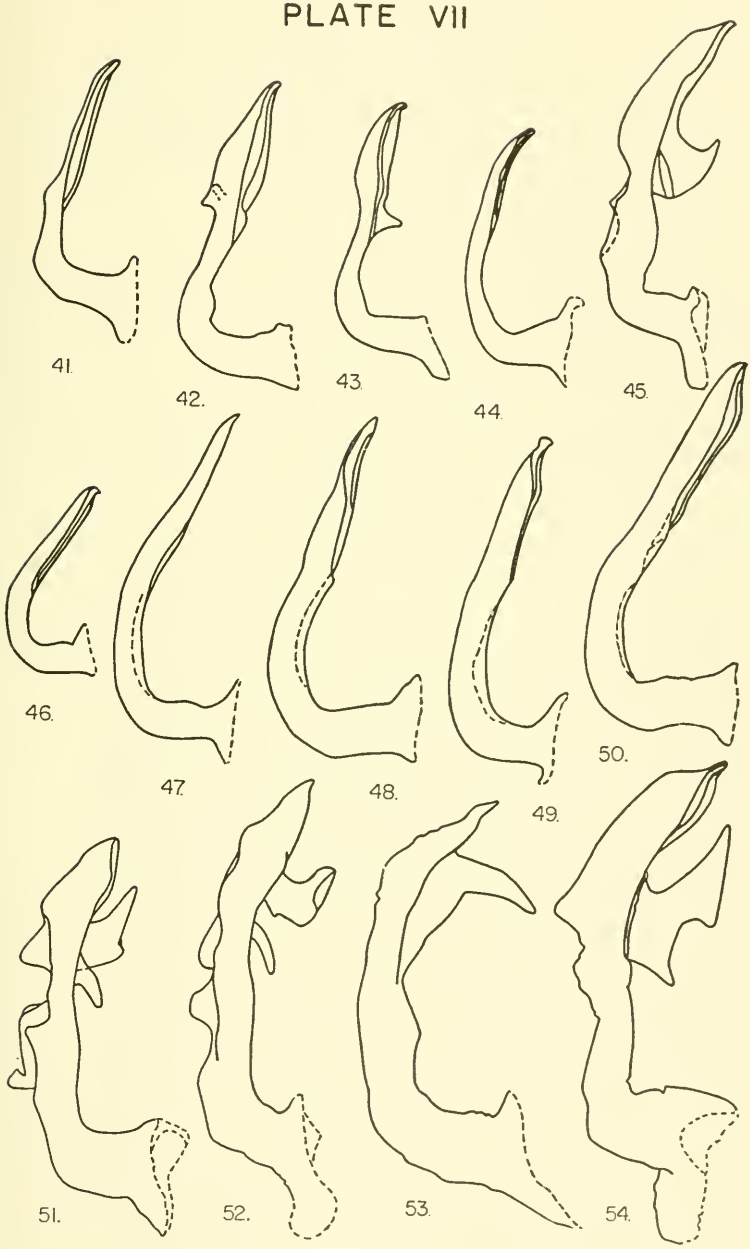


PLATE VIII

FIG. 55. *N. montandoni* (Melin). Abdominal sternites and portion of right clasper of male genitalia.

FIG. 55a. *N. montandoni* (Melin). Enlarged portion or right clasper of male genitalia.

FIG. 56. *N. ater* (Melin). Abdominal sternites and portion of right clasper of male genitalia.

FIG. 56a. *N. ater* (Melin). Enlarged portion of right clasper of male genitalia.

FIG. 57. *N. unicornis* (Melin). Abdominal sternites and portion of right clasper of male genitalia.

FIG. 57a. *N. unicornis* (Melin). Enlarged portion of right clasper of male genitalia.

FIG. 58. *N. ecuadorensis* (Melin). Portion of right clasper of male genitalia.

FIG. 59. *N. borealis* (Melin). Portion of right clasper of male genitalia.

FIG. 60. *N. hungerfordi* n. sp. Abdominal sternites of male.

FIG. 61. *N. tenebrosa* n. n. Abdominal sternites of male.

FIG. 62. *N. terrestris* (Kevan). Abdominal sternites of male.

FIG. 63. *N. fuscipes* (Guérin-Méneville). Abdominal sternites of male.

FIG. 64. *N. raptoria* (Fabricius). Abdominal sternites of male.

FIG. 65. *N. peruviana* (Montandon). Abdominal sternites of male.

FIG. 66. *N. manni* n. sp. Abdominal sternites of male.

FIG. 67. *N. parvula* (Signoret). Abdominal sternites of male.

FIG. 68. *N. amplicollis* (Stål). Abdominal sternites of male.

PLATE VIII

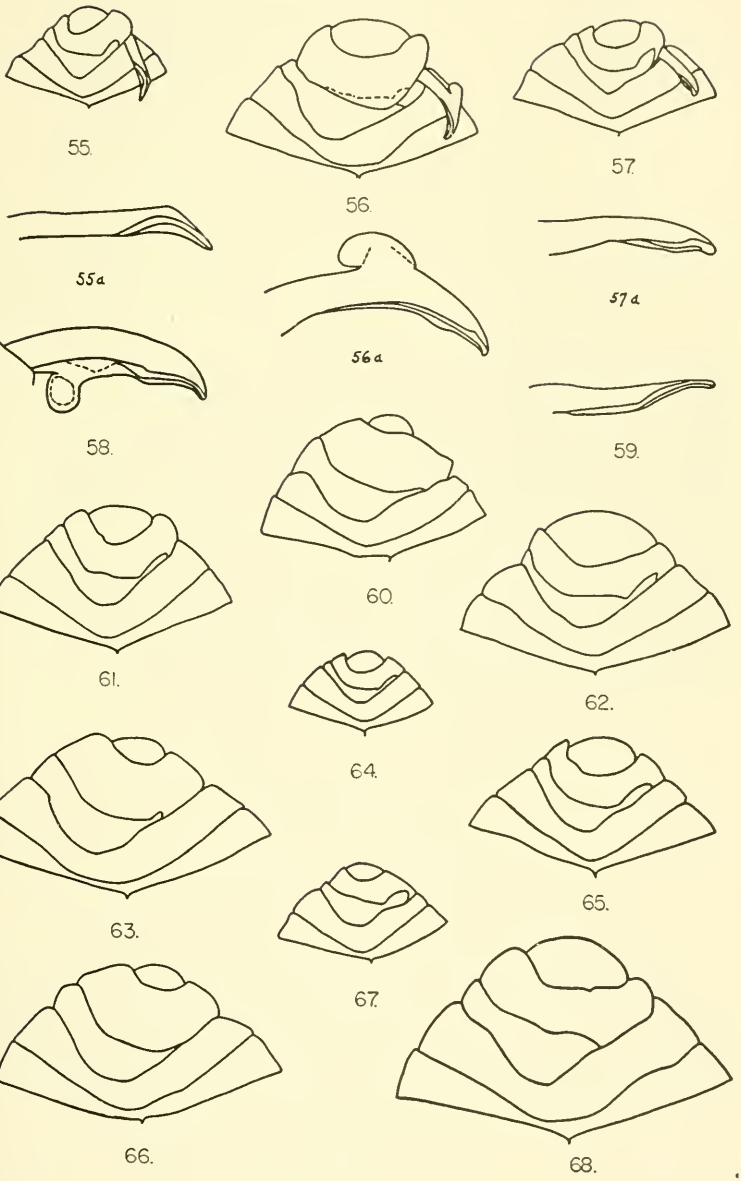
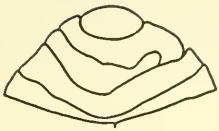


PLATE IX

FIG. 69. *N. mexicana* (Melin). Abdominal sternites of male.
FIG. 70. *N. martini* Todd. Abdominal sternites of male.
FIG. 71. *N. bracchialis* n. sp. Abdominal sternites of male.
FIG. 72. *N. nepaeformis* (Fabricius). Abdominal sternites of male.
FIG. 73. *N. ecuadorensis* (Melin). Abdominal sternites of male.
FIG. 74. *N. nepaeformis* (Fabricius). Front margin of head.
FIG. 75. *N. martini* Todd. Front margin of head.
FIG. 76. *N. fuscipes* (Guérin-Méneville). Front margin of head.
FIG. 77. *N. unicornis* (Melin). Front margin of head.
FIG. 78. *N. hungerfordi* n. sp. Abdominal sternites of female.
FIG. 79. *N. bracchialis* n. sp. Abdominal sternites of female.
FIG. 80. *N. manni* n. sp. Abdominal sternites of female.

PLATE IX



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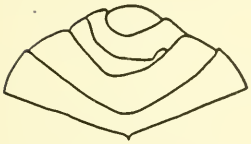

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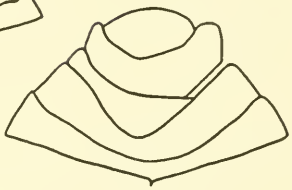

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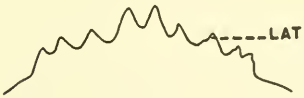

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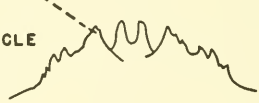

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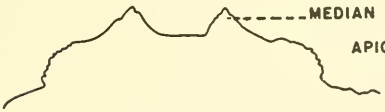

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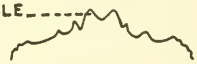

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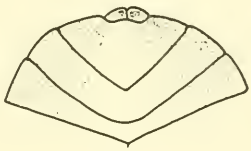

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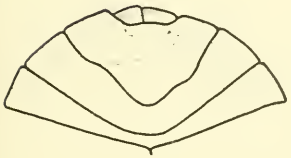

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PLATE X

Abdominal Sternites of Female.

FIG. 81. *N. ranina* (Herrich-Schäffer).
FIG. 82. *N. buenoi* n. sp.
FIG. 83. *N. peruviana* (Montandon).
FIG. 84. *N. quinquedentata* (Melin).
FIG. 85. *N. montandoni* (Melin).
FIG. 86. *N. ecuadorensis* (Melin)
FIG. 87. *N. terrestris* (Kevan).
FIG. 88. *N. raptoria* (Fabricius).
FIG. 89. *N. fuscipes* (Guérin-Méneville).
FIG. 90. *N. rudis* (Melin).
FIG. 91. *N. martini* Todd.
FIG. 92. *N. tenebrosa* n. n.
FIG. 93. *N. nepaeformis* (Fabricius).
FIG. 94. *N. mexicana* (Melin)
FIG. 95. *N. amplicollis* (Stål).

PLATE X

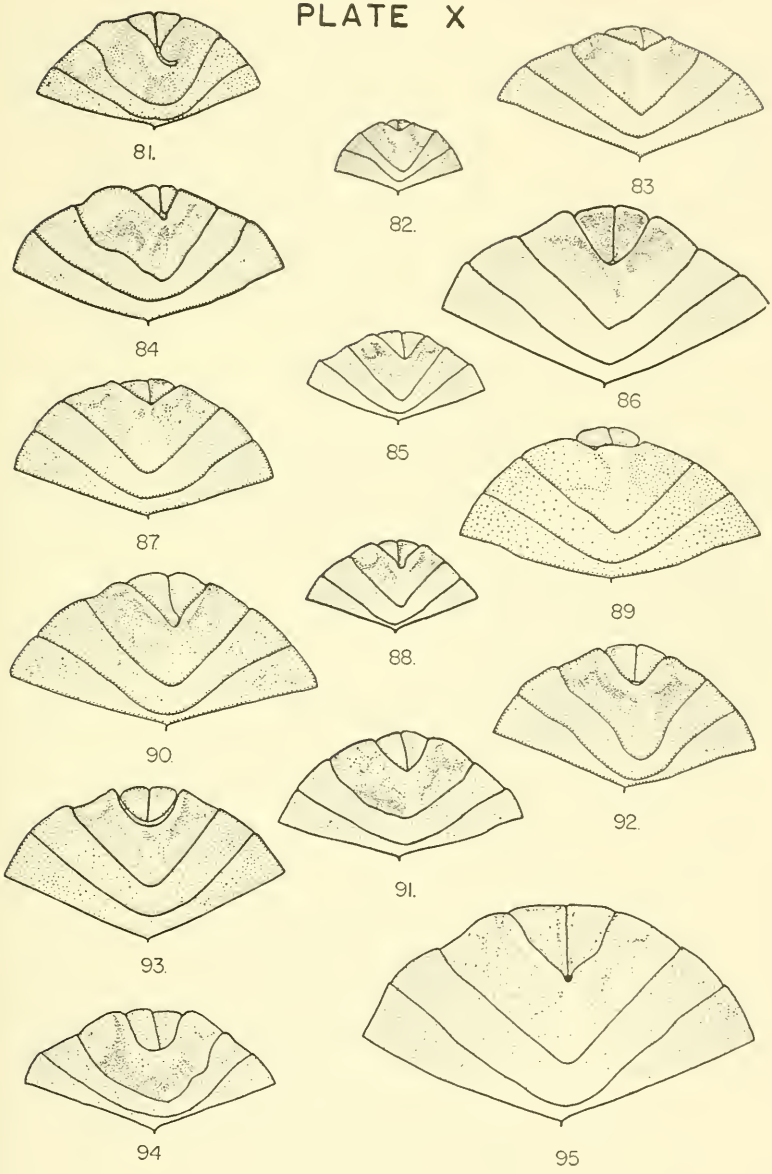


PLATE XI

Right Clasper of Male Genitalia

FIG. 96. *N. grandicollis* (Germar). This does not represent a true ventral view, but rather a ventrolateral view.
FIG. 97. *N. lobata* (Montandon).
FIG. 98. *N. indica* (Atkinson).
FIG. 99. *N. nudata* n. sp.
FIG. 100. *N. omani* n. sp.
FIG. 101. *N. spissa* (Distant)
FIG. 102. *N. robusta* n. sp.
FIG. 103. *N. macrostyla* n. sp.

PLATE XI

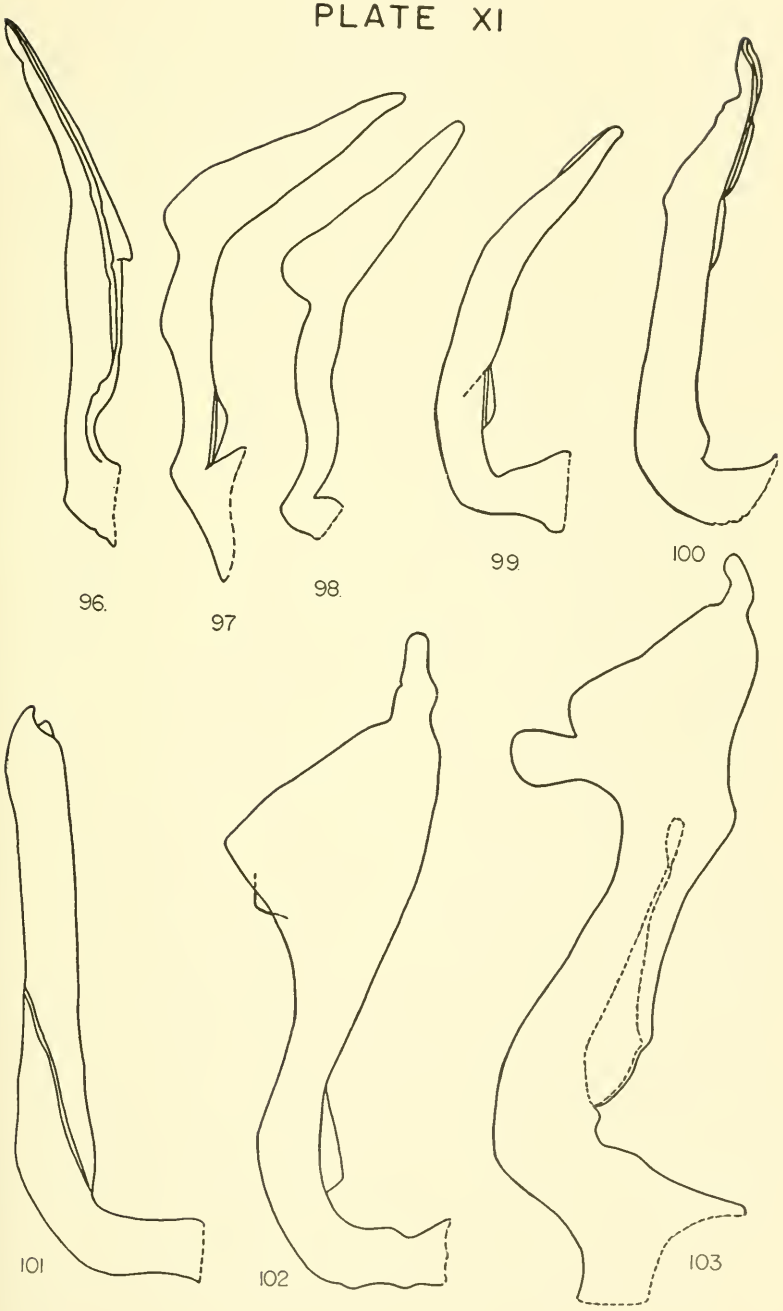


PLATE XII

Right Clasper of Male Genitalia

FIG. 104. *N. tuberculata* (Montandon).
FIG. 105. *N. femoralis* (Montandon).
FIG. 106. *N. grandis* (Montandon).
FIG. 107. *N. luteovaria* (Distant).
FIG. 108. *N. laticollis* (Guérin-Méneville).
FIG. 109. *N. gurneyi* n. sp.
FIG. 110. *N. stygica* Say. Apical portion.
FIG. 111. *N. ampliata* (Montandon).
FIG. 112. *N. williamsi* n. sp.
FIG. 113. *N. macrothorax* (Montrouzier). Apical portion.
FIG. 114. *N. alaticollis* (Stål).
FIG. 115. *N. americana* (Montandon).
FIG. 116. *N. mixta* (Montandon). Apical portion.

PLATE XII

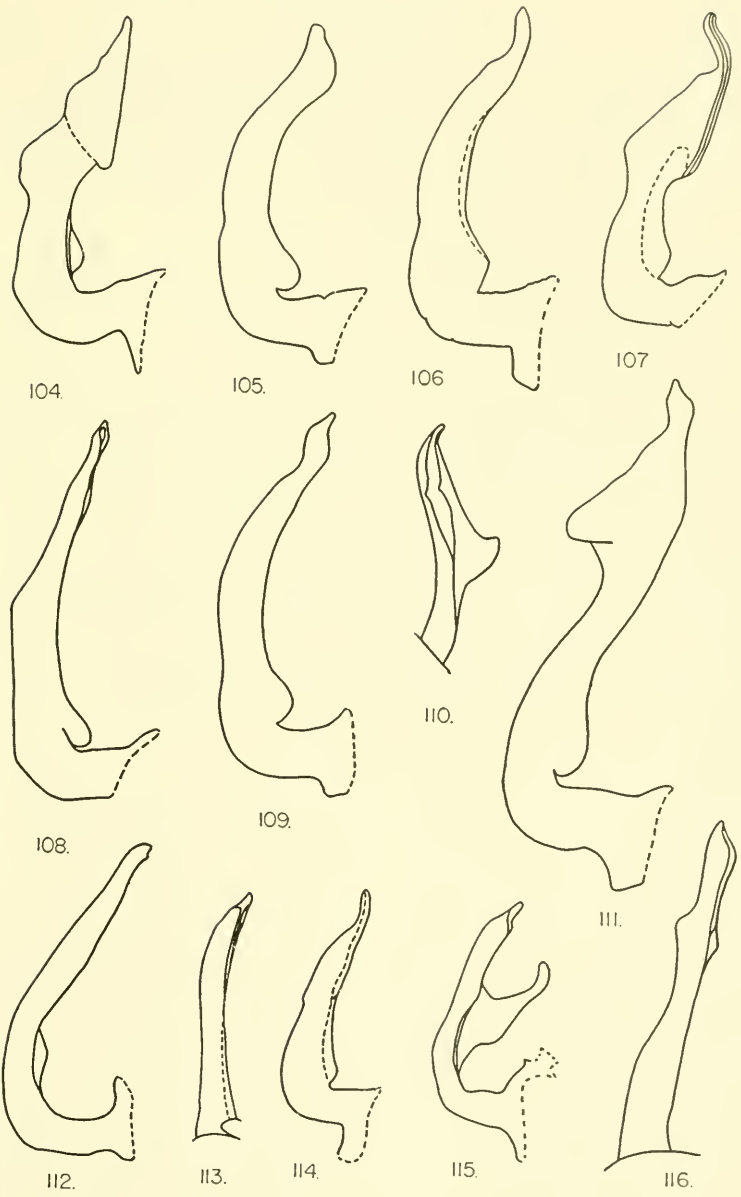


PLATE XIII

FIG. 117. *N. stygica* Say. Abdominal sternites of female.
FIG. 118. *N. alaticollis* (Stål). Abdominal sternites of male.
FIG. 119. *N. macrothorax* (Montrouzier). Abdominal sternites of male.
FIG. 120. *N. americana* (Montandon). Dorsal view of male.
FIG. 121. *N. rugosa* (Desjardins). Dorsal view of female.
FIG. 122. *N. adspersa* (Stål). Dorsal view.
FIG. 123. *N. grandis* (Montandon). Abdominal sternites of male.
FIG. 124. *N. nervosa* (Montandon). Portion of pronotum and left hemelytron of female.
FIG. 125. *N. stali* (Montandon). Dorsal view of female.
FIG. 126. *N. grandis* (Montandon). Dorsal view of female.

PLATE XIII

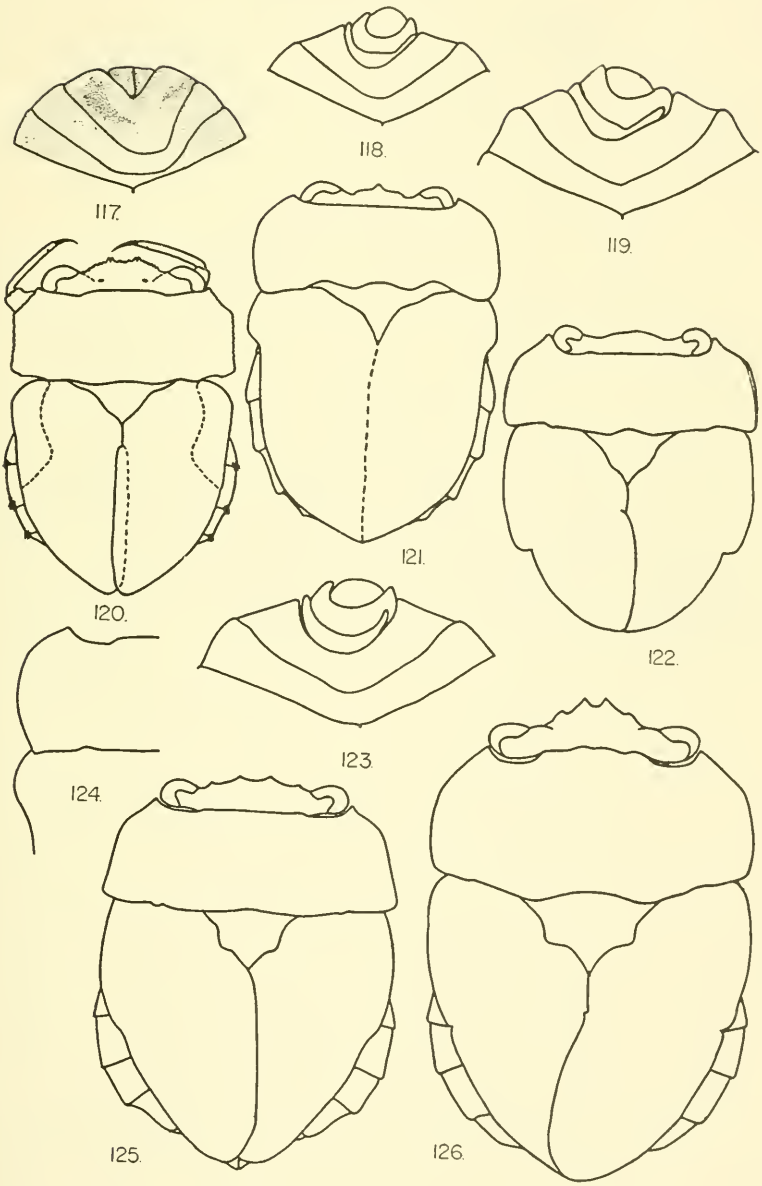


PLATE XIV

FIG. 127. *N. alaticollis* (Stål). Abdominal sternites of female.
FIG. 128. *N. asiatica* (Horvath). Abdominal sternites of female.
FIG. 129. *N. grandis* (Montandon). Abdominal sternites of female.
FIG. 130. *N. stygica* Say. Dorsal view of female.
FIG. 131. *N. sinuosa* n. sp. Abdominal sternites of female.
FIG. 132. *N. hirsuta* n. sp. Abdominal sternites of female.
FIG. 133. *N. stali* (Montandon). Abdominal sternites of female.
FIG. 134. *N. sinuosa* n. sp. Dorsal view of female.
FIG. 135. *N. macrothorax* (Montrouzier). Dorsal view of female.

PLATE XIV

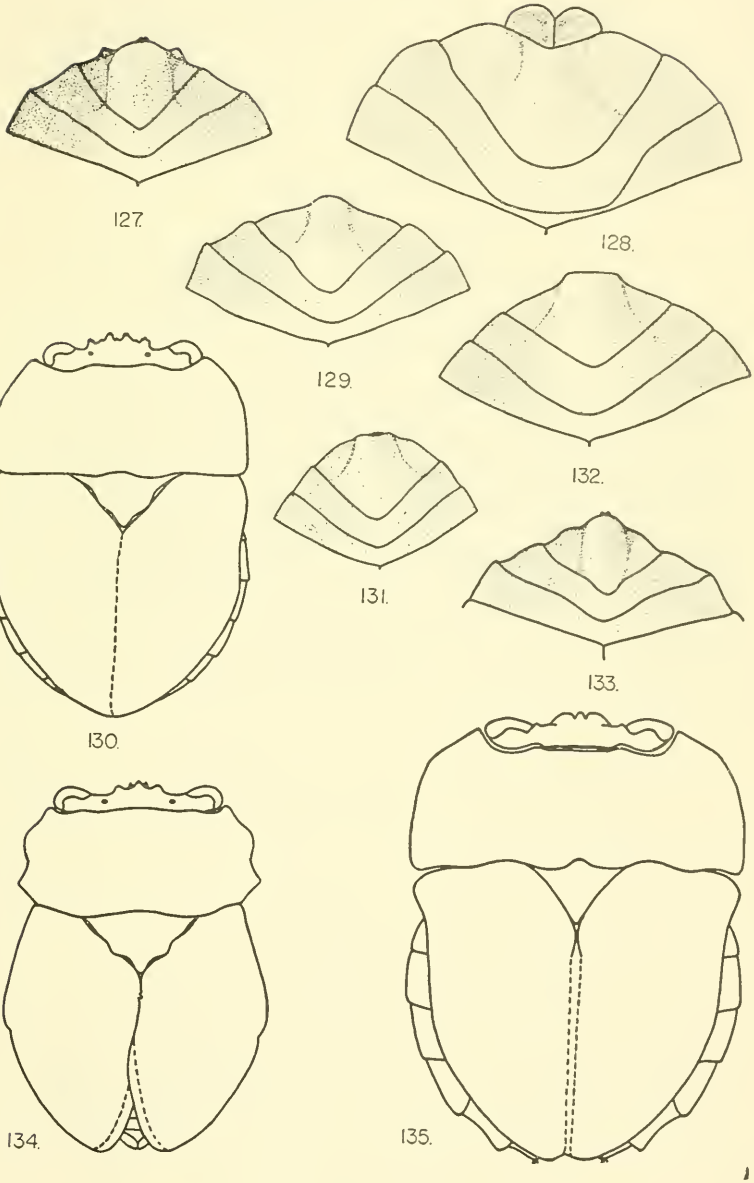
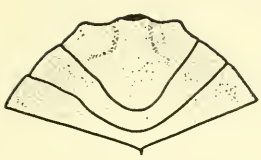


PLATE XV

FIG. 136. *N. luteovaria* (Distant). Abdominal sternites of female.
FIG. 137. *N. tuberculata* (Montandon). Abdominal sternites of female.
FIG. 138. *N. lobata* (Montandon). Abdominal sternites of female.
FIG. 139. *N. laticollis* (Guérin-Méneville), Abdominal sternites of male.
FIG. 140. *N. robusta* n. sp. Abdominal sternites of male.
FIG. 141. *N. usingeri* Todd. Right clasper of male genitalia.
FIG. 142. *N. walkeri* n. sp. Right clasper of male genitalia.
FIG. 143. *N. tasmaniensis* n. sp. Right clasper of male genitalia.
FIG. 144. *N. corudis* n. sp. Abdominal sternites of male and apical portion of right clasper.
FIG. 145. *N. corudis*, n. sp. Enlarged apical portion of right clasper of male genitalia.

PLATE XV



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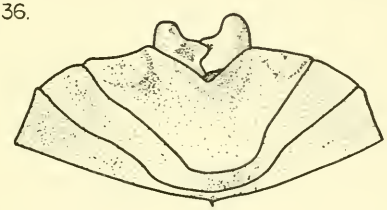

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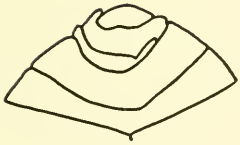

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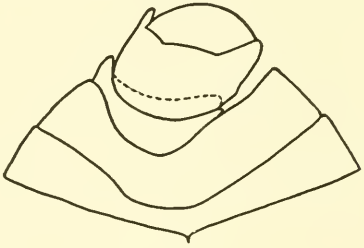

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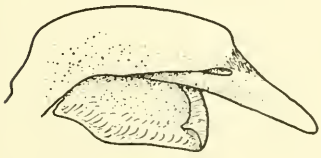

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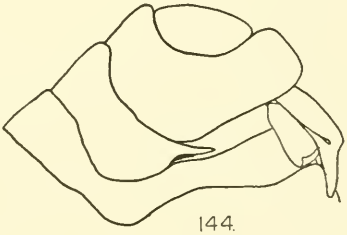

144.

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XXXVII, PT. I] OCTOBER 15, 1955 [NO. 12

Studies of the Agar-Plate Precipitin Test [1]

BY

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Department of Zoology, University of Kansas
Lawrence, Kansas

ABSTRACT: Modifications of Ouchterlony's Petri-plate, agar-diffusion method for performing precipitin tests have been described. Minor changes in the preparation of the agar, the use of plastic molds to form the wells which receive the serological reagents, and the addition of dyes to color the agar are discussed. A simple technique for making permanent photographic records of the zones of precipitation is reported. Homologous and cross reactions are illustrated. A manner in which independent serological systems may approximate true cross reactions in their appearances is illustrated. Photographic records of the development of zones of precipitation using the α- and β- precipitin tests are presented.

INTRODUCTION

Ouchterlony (1948) described an excellent method for qualitatively analyzing soluble antigens and antibodies on a Petri plate containing agar. Antigens and antibodies diffuse through the agar from wells so arranged that the planes of diffusion are at right angles to each other. A visible zone of precipitation forms where the reagents combine in proper proportions. Bjorklund (1952a, 1952b) employed the method in a preliminary analysis of serological components in hemopoietic tissues of rabbits. Oudin (1952), by means of his "simplifying hypotheses," discussed the theoretical basis for antigen-antibody reactions in gels. He pointed out (p. 371) that the relative concentrations of the antigens and antibodies influenced both the location of the zone of precipitation and the time of its appearance. In order to detect all zones, he suggested that

1. These studies were aided by a contract between the Office of Naval Research, Department of the Navy, and the University of Kansas, NR 163-012.

2. Public Health Service Predoctorate Research Fellow of the National Microbiological Institute.

the plates be examined at intervals over a period of several days. In multiple systems, where several antigens and antibodies are interacting, the successive appearance of the zones, and the progressive manner in which each zone develops require that a series of permanent records be made of the zones of precipitation in the plates in order to facilitate accurate analyses. Various types of tracings, diagrams and photographs of the zones have been used to illustrate the end results of experiments. No reports have been published in which the daily changes in the agar-plates are accurately recorded in simple fashion. Oudin's suggestion (p. 365) to place the plates on photographic paper and to make contact prints seemed to us to be the most promising.

We are applying the Ouchterlony method to the study of the precipitin reaction itself, and in comparative serological analysis of the hemocyanins of several arthropods. We modified the method in several ways that improved the quality of our results. The purposes of this report are to describe the Petri-plate, agar-diffusion method as it has been employed in our laboratory, to present a simple technique for making permanent photographic records of the zones of precipitation as they occur in the agar, to illustrate the development of the zones of precipitation during a 7-day diffusion test, to picture homologous and cross reactions, to show how independent serological systems may approximate true cross reactions in their appearances, and to illustrate the influence of dilution of the antigen and the antiserum upon the characteristics of the zones of precipitation.

MATERIALS AND METHODS

Agar. Agar-preparations must be as transparent as possible in order not to mask small, diffuse zones of precipitation. Various brands and qualities of agar were used as were various chemical and mechanical means of clarifying the preparations. Best results were obtained with the following procedures:

Place 66 grams of granulated, Difco Bacto-agar into a four-liter Ehrlenmeyer flask with two liters of distilled water and heat in a steam sterilizer at 18 pounds of pressure for 15 minutes. Remove from autoclave, add, gradually, 300 ml. of 0.5 percent calcium chloride to the hot agar, and manually rotate flask gently until the flocculation of calcium sulfate occurs. Pour the hot agar into two, 1000 ml. beakers and permit it to solidify. Cut the solidified agar into cubes approximately one cm. on a side, place cubes into a large container and wash in running tap water for three days. Drain off excess water and remelt cubes. Dilute liquid agar with an equal volume of 1.6 percent solution of sodium chloride buffered to pH7 with M/75 dibasic sodium phosphate and M/75 mono-

basic potassium phosphate. While the agar is still hot, add 120 mg. of trypan blue, and 52 ml. of a 1.0 percent solution of "Merthiolate." Reheat the agar in the steam sterilizer for 15 minutes at 15 pounds of pressure. Filter the preparation in a Buckner funnel through No. 5 Whatman paper into a warm four-liter, side-arm flask, applying gentle suction to speed the filtration. Pour the filtered agar into large, clean beakers and permit it to solidify. Cut agar into cubes. Store at room temperatures in plastic covered containers. Portions of the stock agar-preparation can be remelted and poured into Petri plates as desired.

During storage of the agar, water is gradually expressed from the cubes but seems not to alter the usefulness of the agar. We have stored preparations for periods up to 30 days without apparent changes in the results obtained from serological tests in which the agar was used. Aluminum foil is not satisfactory as a dust cover for the agar. During prolonged storage, vapor from the agar causes the aluminum to deteriorate.

Petri plates containing agar should be used within a few hours, and never more than 24 hours, after plates are poured. After longer periods, sufficient dehydration occurs in unused plates, even when covered, to cause aberrant results. Moreover, when "old" plates are used in serological tests, cracks may appear in the agar, usually at the corners of the wells, after four or five days and interfere with the tests. Storing the stock of the agar-preparation, or the poured-plates, in the refrigerator is not recommended because the agar becomes opalescent and does not completely clarify when brought back to room temperatures or higher.

Mold assembly. For making the reservoirs into which the solutions of antigens and antibodies are placed, Ouchterlony employs two or three metal molds 10 mm. on a side, mounted together in a fixed position. Each mold is pierced by a central hole to avoid sucking up agar when the assembly is withdrawn. We have found that an assembly of five plastic molds (10 mm. x 10 mm. x 15 mm.) made of transparent cellulose acetate is satisfactory. "Plexiglass" from the Rohm and Haas Company or "Lucite" from the Tennessee Eastman Corporation have been used to make the assembly. Four molds are arranged in a hollow square so that adjacent surfaces are 20 mm. apart. The fifth mold is centered among them so that its corners are in apposition to the corners of the outer molds (Pl. I). Mounting the molds in fixed symmetrical positions provides a constant geometry which is useful when critical comparisons are to be made among different preparations of proteins or among several antisera.

Pouring the agar. Following Ouchterlony's method, the bottoms of the Petri plates are first covered with a thin layer of agar which is allowed to cool; the mold-assembly is placed on the surface of the agar, and another layer of agar approximately three mm. in depth is poured. Capillary migration of the liquid agar up the sides of the molds elevates the rims of the wells above the plane surface of the gel. The elevated rims are objectionable in that they interfere with the photographic recording of zones of precipitation situated close to the wells. In an attempt to avoid the elevated rims we coated the molds with materials such as paraffin, detergents, and silicone to change the amount of wetting by the agar. General Electric's Silicone SF-81 (403)-13308 N-#8, gives the best results, although some capillary movement still occurs. Permitting the agar-solution to cool to 50-56° C before pouring it is an additional aid. The mold-assembly is removed with a quick, vertical pull as soon as the agar is completely gelled.

"Merthiolate" was added as a bacteriostatic agent to the solutions of antigens and antisera, as well as to the agar. We found a dilution of 1:10,000 (0.01 percent) to be most satisfactory. The covers of the Petri plates can be removed frequently for the addition of reagents, for the observation of the zones of precipitation, or for photographic purposes, but excessive drying should be avoided.

Normal practice in our laboratory is to fill the wells with the solutions of serological reagents, and then refill the wells as necessary. Twelve hours is the most common interval between fillings. Five to six ml. of solution is sufficient to run a test for seven to ten days. Most satisfactory for transferring solutions to the wells is a dropping pipette with a tube eight inches long, and one-fourth inch in diameter manufactured by Glasco Products, Chicago, Illinois. All tests have been run at room temperature (24-26° C). Wet inserts of filter paper or paper toweling fitted to the inside of the lids of the Petri plates reduce evaporation of the serological reagents and prevent the formation of droplets of liquid which could fall on the plate and influence the results of the test. The paper is soaked with water, as necessary, to make it adhere continuously to the glass.

In comparisons of antigens, the antiserum generally is placed in the central well, while in the investigation of properties of different antisera it is convenient to place the antigen in the central well. Appropriate control solutions may be employed as required.

Photographic record. Daily photograms of the zones of precipitate are readily made by placing the plates over photographic paper,

making a suitable exposure, and treating the exposed paper as an ordinary photographic print.

Dyes may be used to color the agar and improve the photographic contrast between the zones and the surrounding medium. Bjorklund (1952a) took ordinary photographs of the precipitates in his Petri-plates and used methyl-orange and blue sensitive film to obtain pictures of high contrast. We have employed methyl-orange and red-insensitive Kodabromide No. 5 photographic paper to make satisfactory photograms. Hemoglobin in the solutions results in the appearance of white "halos" around the wells on the photograms of the plates (Pl. II, figs. 5 and 6) colored with methyl-orange. Since the zones of precipitate are recorded as white also, the whiteness of the "halo" tends to mask them. Solutions of proteins which are essentially colorless are not troublesome in this respect.

We experimented with a selection of dyes and photographic exposures in order to improve the photograms. The agar was colored with the following kinds and amounts of dyes:

Methyl orange	33 mgs/100 cc of agar
Methyl green	0.1 cc of a 1% aqueous solution/50 cc of agar
Methyl violet	0.1 cc of a 1% aqueous solution/50 cc of agar
Crystal violet	30 mgs/1000 cc of agar
Trypan blue	30 mgs/1000 cc of agar

Photograms were made by placing a Petri plate, with its cover removed, over a piece of Kodabromide paper No. 5 of sufficient size to record the entire plate. An ordinary photographic enlarger, with the light at an arbitrarily determined, but uniform, distance from the plate was used as a light source. While it is convenient, an enlarger is not necessary, and any concentrated light source employed in an otherwise darkened room, would serve as well. The photograms of the plates colored with trypan blue gave greatest contrast between the zones of precipitation and the agar. The "halo" effect obtained in methyl orange plates was absent, and the boundaries of the basins were clearly delimited. Photograms of the blue-plates were sensitive enough to record the lint which adheres to the surface of the agar, finger prints on the glass and agar, defects in the glass, and other miscellaneous marks and smudges. All of these artifacts are easily identified in the photogram and hence, make possible the most accurate reading of the serological reaction which has occurred in the agar. None of the dyes interfered with the formation of the zones of precipitation. A blue, glass-marking (or wax) pencil was used to record pertinent information about each test on the underside of the dish. If the pencil-

markings are printed or written in mirrored writing, they are recorded properly on the photogram, and together with zones of precipitate form a complete record of the test on the photographic paper. By appropriately altering the concentration and the color of the dye, the time of exposure, and the kind of photographic paper used, useful photograms can be obtained under a variety of conditions.

Antigen-antibody system. The hemocyanins from two species of arthropods, the king crab *Limulus polyphemus* and the blue crab *Callinectes sapidus*, were injected intravenously and concurrently into a rabbit. Three series of ¼, ½, 1, and 2 ml. doses of each antigen were given (Leone 1952). The resulting antiserum was tested with each antigen and with a pooled sample composed of both antigens (Pl. I). The concentration of the antigens was 3.0 grams percent in the wells containing the hemocyanins of either species. Protein levels in the wells containing the pooled sample were adjusted so that the effective concentration of each antigen was also 3.0 grams percent. The solution of hemocyanin of one species was used as diluent for the other.

A hyperimmune antiserum was produced in a rabbit against the hemocyanins of the edible crab *Cancer magister*. Five series of injections, of ¼, ½, 1, and 2 ml. doses, were given (Leone, 1952). The antiserum was used to analyze the influence of the relative concentrations of antigens and antibodies on the zones of precipitation which formed in the agar (Pls. III and IV). In the tests involving varying concentrations of antigen and a constant concentration of antibodies, a doubling-dilution sequence of the hemocyanins was prepared, beginning with a solution of 6.39 grams percent protein, a dilution of 1:15.625 (Well No. 1, Pl. III), and ending with a dilution of 1:256,000 (Well No. 16, Pl. III). The doubling-dilutions were placed in the wells in the regular sequence (Pl. III, Cell Nos. 1 through 16). Undiluted antiserum was placed in the central well (XM). In the tests involving varying concentrations of antibodies and a constant concentration of antigen (Pl. IV), a doubling-dilution sequence of the antiserum was prepared, the greatest dilution being 1:128 (Pl. IV, Cell Nos. 1 through 8). A solution of antigen containing 6.39 grams percent of hemocyanin was placed in the central well (M) and the dilutions of antisera were placed in sequence in the outer wells.

Descriptive terms. We have found it necessary to adopt a series of terms to describe uniformly the serological reactions which

occur in the agar. Oudin (1952) has provided a number of useful terms such as: *zone of precipitation, coalescence of zones, partial coalescence of zones,* and *intersection of zones.* Zones are qualitatively differentiated in our laboratory as to appearance by designating them as *broad* or *narrow,* and *dense* when they were opaque, or *diffuse* when they were translucent. In some tests, more precise comparisons among zones are possible by measuring their widths on the photograms. The characteristics of a zone of precipitation changes as a reaction progresses. For example, a zone after 1 day may appear as short, narrow and dense; after 7 days it may be greatly elongated, broad and dense in its *medial* region, and be narrowing and *diffuse* in its *lateral* regions. The *medial* region of a zone is that portion which develops between the adjacent corners of the well containing antigen and the well containing antiserum. As the zone continues to grow in length its *lateral* portions may coalesce with, or intersect, other zones. In multiple precipitating systems several zones of precipitation often appear between the wells containing the reactants. The position of a zone is described as being *more* or *less central,* according to its relative nearness to the central well. Zones usually are referred to as being *opposite* a given reference-well when they occur between the wells containing the reactants, and *between* two wells when the wells in question contain only one kind of serological reagent, that is either antigens or antisera.

EXPERIMENTAL RESULTS

Plate I illustrates the daily growth and development of zones of precipitation, some of which coalesce whereas others intersect. The zones grow in length and thickness. By three days of diffusion-time two zones of precipitation appeared between the wells containing antiserum (XCL) and the hemocyanin of *Callinectes* (C), and three zones appeared between the walls containing the antiserum and the hemocyanin of *Limulus* (L). The wells marked CL contained a mixture of the hemocyanins of the two species. Only two zones of precipitation appear opposite the CL-wells at four days. Five zones could be expected in view of the fact that all of the zones between the C- and L-wells intersect. The rabbit produced no antibodies which were reactive with the hemocyanins of both *Callinectes* and *Limulus.* It is obvious that the zones of precipitation opposite the CL-wells are superimposed upon one another. As would be expected, between the CL-wells, all of the zones

coalesce, and between the CL-well and the C-well or L-well some of the zones coalesce while others do not.

Plate II, Figure 1 pictures a duplicate of the test shown in Plate I, with the exception that in the second test the wells were not refilled with the serological reagents. A comparison of results obtained by repeatedly filling the wells with those obtained by a single filling is possible. The 0.3 ml. of reagent required to fill each well, developed zones in seven days; the zones were approximately equivalent to the zones shown for four days in Plate I. The zones of precipitation are, however, more sharply defined in Plate II, Figure 1, than in Plate I, and where coalescence and overlapping of the zones have occurred the reactions involving the proteins of either *Callinectes* or *Limulus* are more easily identified. The less central zone between the C- and XCL-wells (Pl. I) did not appear in this test (Pl. II), whereas the most central zone between the L- and XCL-wells was barely visible. There probably was insufficient reagent available to permit the differentiation of these less distinct zones, or to develop the coalescence and intersection of the zones to the degree obtained in Plate I, Figure 6.

Plate II, Figure 2 illustrates the appearance of homologous and cross reactions between the antiserum (XM) produced against the hemocyanins of *Cancer magister* and the sera of four closely related species of crabs: *C. magister* (M), *C. pagurus* (P), *C. productus* (D) and *Carcinus maenus* (E). The "partial-identity reactions" (Ouchterlony 1948) visible between M- and P-wells and M- and E-wells are similar in appearances to the overlapping and independent reactions, pictured in Plate I, Figure 6.

The homologous reaction in Plate II, Figure 2 developed three zones of precipitation, each distinctly different from the other. The most nearly central zone was broad and dense in its medial region, and dense and narrowing in its lateral regions. The middle zone was uniformly narrow and dense. The outer, or least central, zone was broad and diffuse. The variable characteristics of the zones of precipitations for the cross reactions indicate that there are qualitative differences among the hemocyanins of these species. Between P-well (*C. pagurus*) and the antiserum only a single dense zone of uniform width developed. Between D-well (*C. productus*) and the antiserum three zones developed the least central of which was barely visible. *C. productus* more nearly approaches *C. magister* in reactivity than does *C. pagurus*. The coalescing zones between P- and D-wells obviously are equivalent whereas those between D- and E-wells are not. The characteristics of the zone produced by the

cross reaction of hemocyanins from *Carcinus* (E-well) with the antiserum are distinctly different, that is to say, they are more diffuse and tapering, from the characteristics of the cross reaction involving the proteins of *C. pagurus* (P-well). The partial coalescence of the *Carcinus* zone (E-well) with the *C. magister* zone (M-well) obviously is different from the partial coalescence of the latter and the zone for *C. pagurus* (P-well). The photogram is the only form of recording known to the authors which could detect such qualitative differences among precipitin reactions in gels.

Plate III contains the record of the zones of precipitation obtained from a standard α-precipitin test. Photograms of the Petri plates are so arranged that the development of the zones of precipitation for any particular dilution of antigen may be compared in the horizontal rows of figures, and zones of precipitation for all of the dilutions of antigen, at any given time, may be compared in the columns of figures. A study of Plate III reveals that the concentration of antigen of a homologous precipitin reaction conducted in agar, under the conditions stipulated above, influences (1) the characteristics of a zone, that is to say, whether it is dense or diffuse, broad or narrow, of uniform width or tapering; (2) the number of zones of precipitation which develop and the number of zones which are detectable; (3) the relative position of the zones of precipitation between the wells containing the reagents; (4) the time of appearance of a zone of precipitation; (5) the time required for identical zones to coalesce. All five of these factors are variables which must be kept in mind when this agar-diffusion technique is used to analyze protein systems.

The antigen-dilutions of higher concentration were responsible for the development of the largest number of zones. At seven days, opposite Well No. 1 (Pl. III, Fig. 1F), containing 6.39 grams percent protein, there were eight distinct zones, plus another "zone" which appeared to hug the walls of the well. Well No. 2 had seven zones; Well Nos. 3 and 4 had six zones, etc. As the concentration of antigen decreased, the number of visible zones decreased and the positions for the zones moved closer to the antigen-wells. The outer, or less central, zones which are so apparent in Figure 1F, and that are visible to a lesser extent opposite Well Nos. 5 and 6 (Fig. 2F), have disappeared from the agar in the region opposite Well No. 9 (Fig. 3F), and only the zone corresponding to the broad, most central zone in Figure 1F is present. This still-present zone is displaced away from the antiserum-well, as compared to the position it occupied in Figure 1F. The zones of precipitation which formed

opposite Well Nos. 5 and 6 (Fig. 2C) illustrate a situation where the region of coalescence reveals two distinct zones at three days, but by seven days (Fig. 2F) the distinction is obliterated.

No zones were visible opposite Well Nos. 11 and 12 after one day of diffusion (Pl. III, Fig. 3A), but by two days a diffuse zone had appeared. The reactions around Well No. 13 are of special interest. The antigen in the well had a dilution of 1:64,000 (1.81 mgs. percent). No zone of precipitation developed in the agar in the seven days of diffusion. A visible precipitate was deposited, however, around the edges of the Well No. 13 which were closest to the antiserum-well (Figure 4F).

Plate IV illustrates the occurrence of zones of precipitation in a two-dimensional agar-diffusion precipitin test in which β technique (constant antigen-varying antiserum) was used. This hemocyanin-antihemocyanin test is the reciprocal of the α-test illustrated in Plate III. At all of the dilutions of antiserum for which precipitations were visible, the zones were broad medially and narrowing laterally. The densities of the zones were a function of the concentration of the antibodies. Two principal zones of precipitation occurred; the more nearly central zone was narrow and the other zone was broad. As the broad zone developed, it became obvious at the region of coalescence that the precipitate was not deposited homogeneously (Pl. IV, Fig. 1F). Seven zones of precipitation were visible between Well Nos. 1 and 2 after seven days of diffusion. To test whether or not the development of the several zones was an artifact which was a consequence of repeated fillings of the wells, or due to minor fluctuations in temperature during the experiment, the test was repeated employing but a single filling of the wells and a carefully controlled temperature (26° + 0.5° C). The results of the test are shown in Plate II, Figures 3 and 4. Except for the fact that the zones of precipitation had not developed, after seven days, to the same extent as the zones in Plate IV, Figures 1F and 2F, no differences were apparent which could not be ascribed to the limited amounts of reagents available in the control-test. Four zones were visible in the region of coalescence (Pl. II, Fig. 3) and this approximately corresponded to the five-day stage of the original test (Pl. IV, Fig. 1E).

Only in the "undiluted" and "1 + 1" wells (Pl. IV, Fig. 1F, Well Nos. 1 and 2) were the antibodies sufficient to cause the distinct representation of the several zones in the region of coalescence. The zones of precipitation between other wells were too diffuse to

make possible a sure subdivision of the broad zone. The highest dilution of antiserum at which a zone of precipitation was visible was 1:64. This dilution and the next higher dilution (1:128) are, in our experience, typical agar-titers for powerful precipitating antisera produced against hemocyanins.

The principal effect of varying concentration of antibodies upon the zones of precipitation is on their density. To a lesser extent the proximity of a zone to the source of antibodies is also influenced.

DISCUSSION

We have found the five-mold assembly as easy to handle as Ouchterlony's three-mold unit. With the former, simultaneous comparisons among a larger number of serological reagents, and the use of various types of control solutions on the same plate as test solutions, are possible. Grabar and Williams (1954), have employed as many as six wells around the central well.

Diffusion of the solutions of antigens and antibodies from wells of various depths were tried. If the wells were less than 3 mm. deep diffusion and evaporation occurred so rapidly that refilling was needed at frequent intervals. Deeper wells, while making possible the demonstration of the ribbonlike character of the zones when they are viewed at an angle oblique to the vertical, have the disadvantage of introducing the problem of a discontinuous diffusion of the solutions through the agar as a result of the lower portions of the basins always being wet, and the upper portions occasionally being dry.

The photograms proved to be more sensitive than the unaided eye in detecting the presence and extent of the zones of precipitate. For making quantitative measurements of the position of the zones, the photograms have a distinct advantage over Ouchterlony's suggestion of employing a graduated mechanical stage and a cross-hair eye-piece. The positions of the zones may be precisely determined from the photograms by superimposing on the prints a transparent sheet of cellulose acetate paper on which a millimeter grid has been ruled. A standard bacterial-colony counter with a modified grid may also be used for this purpose. Almost unlimited magnification of the plates can be obtained by using a transparency projector such as a Vu-Graph (Charles Beseler Co., Newark, N. J.). This machine will project an image of the plate to any desired size, and at the same time, permit a critical focus of the zones. Large-scale, accurate tracings of the zones can be made readily.

In our experience the practice of refilling the wells with serological reagents resulted in patterns of precipitation which yielded more information concerning the number of reactions going on in the system, than was obtained in experiments where the wells were filled just once. Variations in the results obtained between the two types of tests were only those of degree of development of the zones, and were not any of the effects which could be ascribed to a discontinuous diffusion of reagent through the agar-medium. In addition, we have found that, when solutions of antigen or antiserum were spilled on the agar, the entire plate can be liberally flushed in cold tap water, drained, the wells blotted dry and refilled immediately with the reagents without causing any detectable changes in the patterns of precipitation. If the spilled reagents are not quickly flushed away, precipitates will form on the surface of the agar and these precipitates will mask the underlying zones of precipitation and spoil the photographic qualities of the Petri plate; the spilled reagent will distort also the shapes of the underlying zones, by means of actual immunochemical interference.

An electrophoretic and ultracentrifugal analysis of the serum of *Cancer magister* used in these experiments revealed that only two component-hemocyanins were present. Hemocyanins are known to be the only precipitin-inducing substance in the sera of Crustacea (Tyler and Scheer, 1945). Oudin (1952) has concluded that the appearance of a zone of precipitation in an agar-medium is an indication of a unique reaction between an antigen and its antibody. The fact that more zones of precipitation occur (Pl. III, Fig. 1F) than can be accounted for in the serum on the basis of physicochemically detectable components requires some explanation. Hooker and Boyd (1934) have shown that native proteins of a given species have more than one kind of antigenic radical. Since the most zones of precipitation in the agar-diffusion tests are obtained when both of the reagents are in high concentration (Pl. III, Fig. 1F, Pl. IV, Fig. 1F), it is reasonable to assume that the several zones are serological realities and not artifacts or phenomena analogous to Liesegange rings.

In applying the Ouchterlony method to the analysis of complex mixtures of antigens such as sera or extracts of organs care must be taken that cross reactions are realities and not artifacts which could result from the suprapositioning of unrelated serological reactions. Plate I, figure 4 (or Pl. II, fig. 1) shows zones of precipitation which overlap each other but which are the results of inde-

pendent serological reactions as evidenced by the intersection of all the zones in the region between the C-well and the L-well.

From theoretical considerations (Oudin, 1952; Ouchterlony, 1953) and the empirical knowledge of Ouchterlony (1948) and from the data described above, the location and time of appearance of a zone of precipitation in the agar in the Petri plate are dependent upon the concentrations of the antigens and antibodies involved. Dependent also upon concentration are the number of zones of precipitation which appear, whether or not coalescence or intersection of zones can be realized, and other characteristics of the zones such as their density and width. In tests involving comparisons of reactions of several related antigens with a single antiserum, the most useful data would be obtained when the components of the antigens were in equal and relatively high concentrations unless the concentrations of the components are themselves a variable under investigation.

SUMMARY

Modifications of Ouchterlony's Petri-plate, agar-diffusion method for performing precipitin tests have been described. Minor changes in the preparation of the agar, the use of plastic molds to form the wells which receive the serological reagents, and the addition of dyes to color the agar are discussed. A simple technique for making permanent photographic records of the zones of precipitation is reported. Homologous and cross reactions are illustrated. A manner in which independent serological systems may approximate true cross reactions in their appearances is illustrated. Photographic records of the development of zones of precipitation using the α- and β-precipitin tests are presented.

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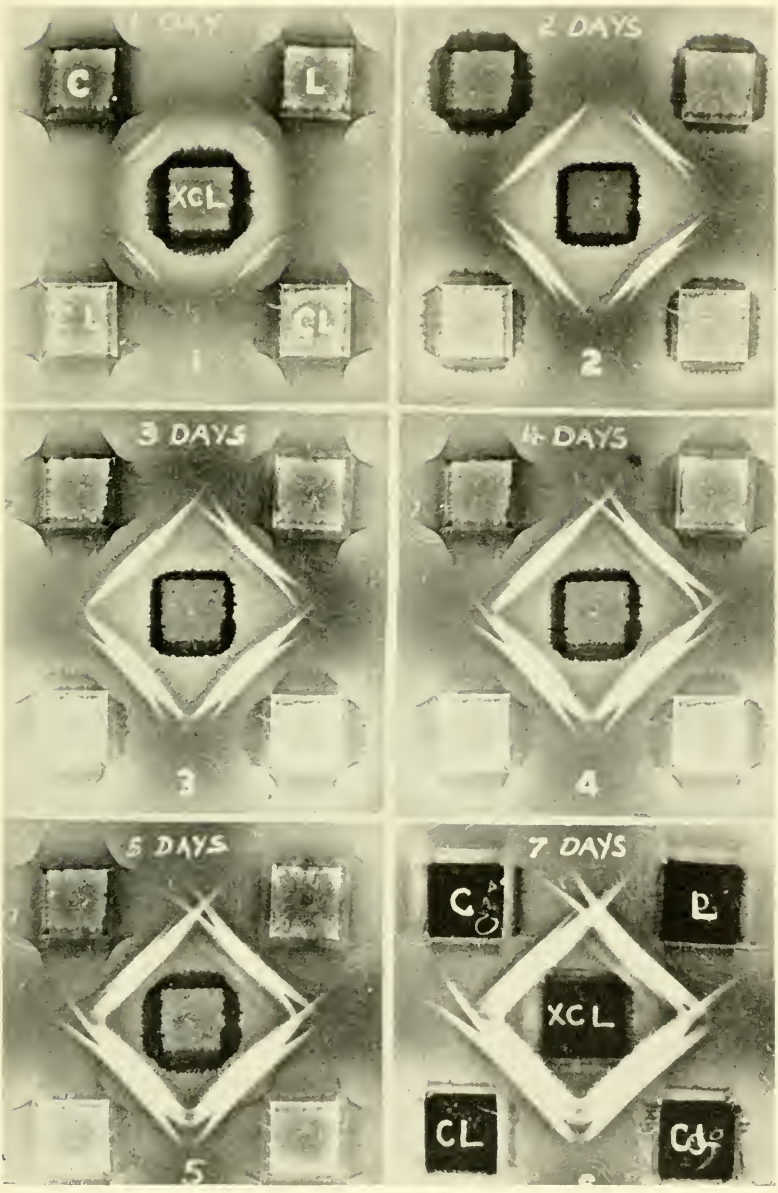
PLATE I

A two-dimensional agar-diffusion test illustrating the development of coalescing and intersectiong zones of precipitation during 7 days of diffusion-time. The peripheral wells contained the hemocyanins of *Callinectes* (C), or *Limulus* (L), or a mixture of both of them (CL). The central well (XCL) contained antiserum which was produced against the mixture of antigens. The intersection of all the zones of precipitation between well C and L indicate that no antibodies were present which could combine with both antigens. Magnification of illustrations: × 1.

PLATE I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3
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7 DAYS
C
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XCL
CL
CA
6

PLATE II

FIG. 1. A duplicate of the reaction pictured in Plate I with the exception that these wells were not refilled with reagents. In the regions where they overlap each other, the zones are more sharply defined than in Plate I. The zones were not developed as much in the regions of coalescence and intersection.

FIG. 2. The appearance of homologous and cross reactions between the antiserum (XM) produced against the hemocyanins of *Cancer magister* and the sera of four closely related species of crabs: *Cancer magister* (M), *C. pagurus* (P), *C. productus* (D) and *Carcinus maenus* (E).

FIGS. 3 and 4. A duplicate of the β-precipitin test which is illustrated in Plate IV with the exception that the wells were not refilled with the reagents. The doubling-dilutions of antiserum were placed in sequence in the peripheral wells and the antigen was placed in the central well of each plate.

FIG. 5. An illustration of the "halo" effect which is obtained in photograms when an antiserum containing hemoglobin (central well) diffuses into agar which has been colored with methyl orange.

FIG. 6. A photogram with "halos" obtained from four antisera (peripheral wells) containing hemoglobin. Agar was colored with methyl orange. The numbers in the wells are prints of the mirrored writing on the undersurface of the Petri plate.

Magnification of illustrations: $\times$ 1.

PLATE II

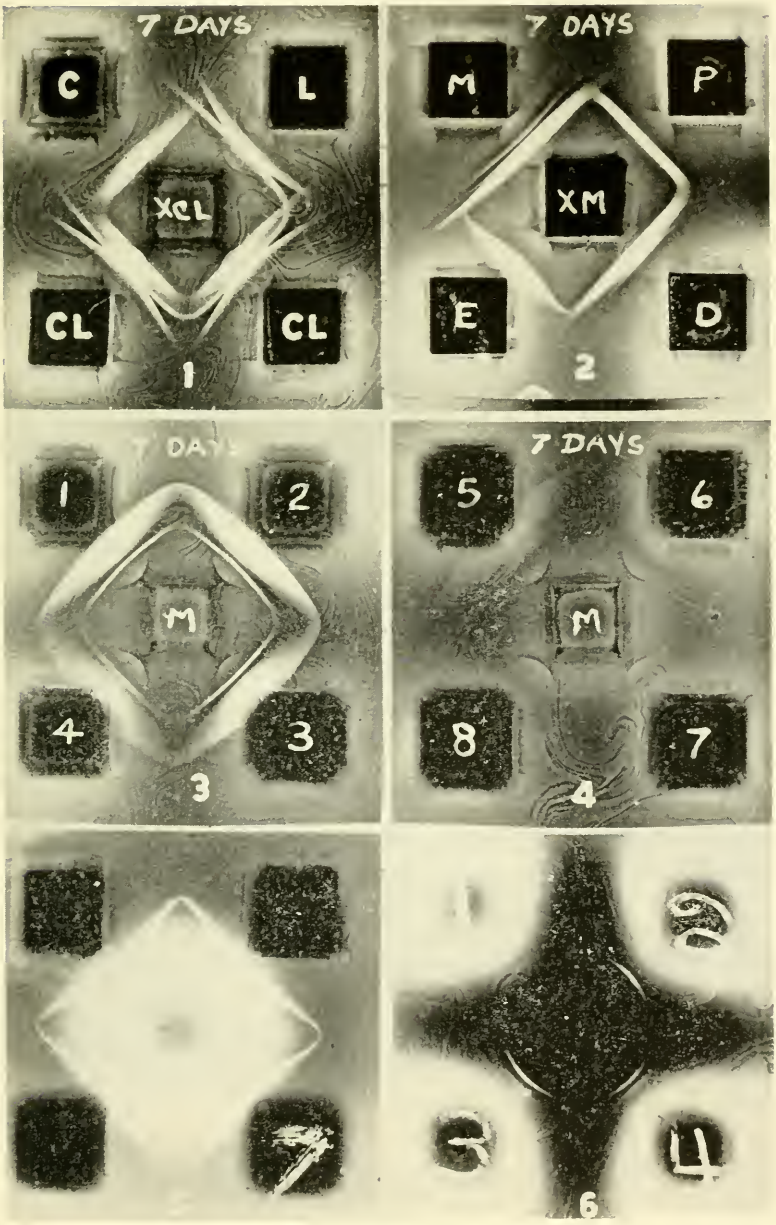


PLATE III

A record of the zones of precipitation obtained in the agar from a standard α-precipitin test with a hemocyanin-antihemocyanin system. Photograms of the Petri plates are so arranged that the development of the zones for any particular dilution of antigen may be compared in the horizontal rows of figures, and the development of the zones for all of the dilutions of antigen, at any given time, may be compared in the columns of figures. The doubling-dilution series of antigen begins in Well No. 1 with one part protein per 15.625 parts saline, and ends in Well No. 16 with a dilution of 1:256,000. Antiserum is located in the central well (XM) of each plate. The serological system is the hemocyanin in the serum of the crab *Cancer magister* and its homologous antiserum. Magnification of illustrations: $\times$ ½.

PLATE III

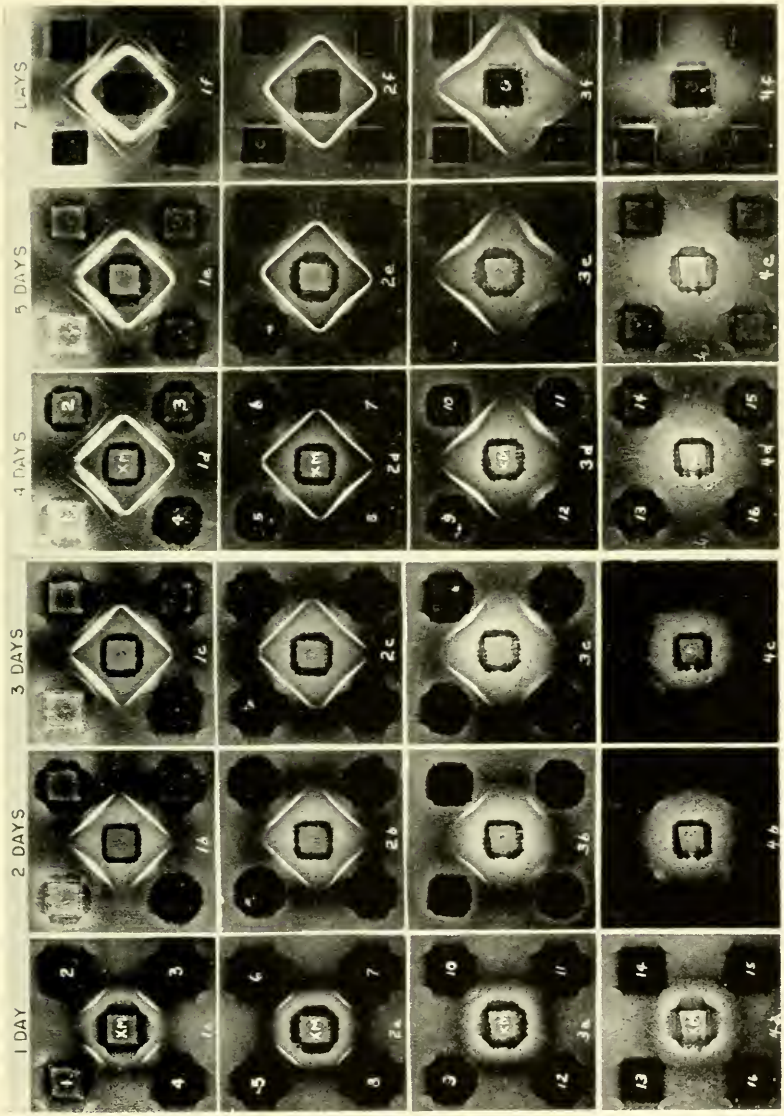
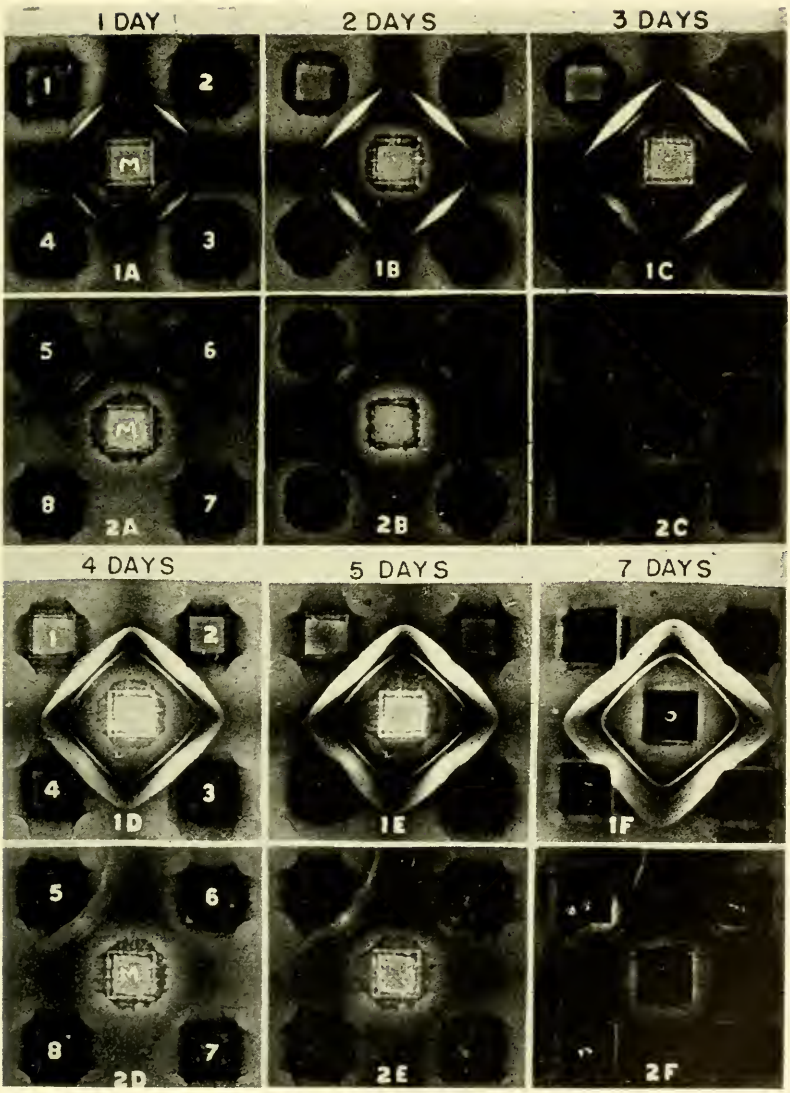


PLATE IV

A record of the zones of precipitation obtained in agar from a standard β-precipitin test with a hemocyanin-antihemocyanin system. Photograms of the Petri plates are so arranged that the development of zones for any particular dilution of antiserum may be compared in the horizontal rows of figures, and development of the zones for all of the dilutions of antiserum, at any given time, may be compared in the columns of figures. The doubling-dilution series of homologous antiserum begins with undiluted antiserum in Well No. 1 and ends in Well No. 8 with a dilution of 1:128. A 6.0 percent solution of the hemocyanins of *Cancer magister* is situated in the central well (M). Magnification of illustrations: $\times$ 2/3.

PLATE IV


1 DAY
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Additions to the Known Herpetological Fauna of Costa Rica with Comments on Other Species. No. II

By EDWARD H. TAYLOR

ABSTRACT: This paper treats of six caecilians, seven Salientia, ten lizards, and five snakes from Costa Rica. Of this number the following are described as new: *Dermophis costaricense, Dermophis occidentalis, Dermophis glandulosus, Eleutherodactylus mimus, Eleutherodactylus vocator, Agalychnis saltator, Anadia metallica arborea, Anadia metallica attenuata, Leposoma southi orientalis, Lepidophyma reticulatum, Lepidophyma anomalum, Lepidophyma ophiophthalmum.*

Atelopus varius loomisi is elevated to species rank and the following are added to the list of Costa Rican species: *Dermophis parviceps, Eumeces managuae, Leptotyphlops ater.*

A fourth journey to Costa Rica was made by me in the summer of 1954. Much of my effort in collecting was made along the Panamanian border of Costa Rica and along the Nicaraguan border in the north. Political difficulties between the two latter countries prevented me from carrying out plans for more extensive collecting in the Caribbean drainage area of the northern border.

Accompanied by Prof. Marco Tulio Pacheco I visited the town of Tilarán and collected chiefly in an area to the northeast at Finca Bosco and Lake Arenal. One trip was taken along the Pan-American Highway to the northern border. One journey was made to Cocos Island, another to the upper reaches of the Saripiquí river.

For the most part my efforts yielded gratifying results. However, an unknown Teiid lizard, seen at an elevation of about 2,425 meters on the west slopes of Cerro de la Muerte, escaped from under my hand, leaving only a wiggling tail as evidence that such a creature occurs. Numerous toad voices of a species not identified, but believed to be a species of *Microhyla,* were heard

at Liberia in late August, but none could be found in the lush vegetation growing in the pools from whence the calls issued.

Despite the collections I have made on four journeys much work must be done before the entire herpetological fauna is collected; and before the details of the distribution of the various species within the country can be authoritatively known.

I wish to acknowledge my grateful thanks to Professor Marco Tulio Pacheco for very numerous specimens and for the assistance rendered by him and members of his family; and to Dr. and Mrs. Leslie Holdridge who were my hosts for a part of the summer.

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CAECILIIDAE

Two genera of this order, *Dermophis* and *Gymnopis*, are recognized in Costa Rica. These genera may be separated by the following key:

Eye present, not covered by bone, usually visible through the skin. One mandibular tooth-series (inner lacking) ..... *Dermophis*

No visible eye, the eye wholly or partially covered by bone in the fully grown specimen; two mandibular tooth-series, the inner consisting of one or more teeth (splenial) on each side. ..... *Gymnopis*

Genus Dermophis Peters

Dermophis Peters, Monatsb. Akad. Wiss. Berlin, 1879, p. 937 (no type mentioned); Boulenger, Catalogue of the Batrachia Gradientia s. Caudata and Batrachia Apoda in the collection of the British Museum, 1882, p. 97 (repeats in English Peters' definition. Includes six species (one of which is African), some of which have the inner mandibular series, others do not); Noble, Bull. Amer. Mus. Nat. Hist., vol. 49, no. 11, 1924, p. 305.

Gymnopis Dunn (*part.*) Bull. Mus. Comp. Zool. Harvard Coll., vol. 91, no. 6, 1942, p. 461 (combines *Dermophis, Gymnopis* and *Cryptosophis*).

The original definition of *Dermophis* Peters reads as follows: "Augen sichtbar. Tentakelgrube kreisförmig vor und unter dem Auge, Tentakel kugelförmig; Körper mit dachziegelförmigen Schuppen. Unterkieferzähne in zwei Reihen." "America und Afrika." Peters listed under the genus, *Dermophis mexicanus, proximus, simus, brasiliensis, brevirostris*, and *thomensis*. No type was designated but Dr. G. K. Noble, in 1924, named *mexicanus* the type, perhaps without being aware that *mexicanus* did not agree fully with the generic description. Dunn, 1942, likewise seemingly was unaware of this.

Peters stated that the genus had two mandibular tooth-rows but included *mexicanus* that has only a single row. Since the latter has become the type of the genus by designation, it is necessary to correct the generic definition or by a suspension of rules designate a type that has two rows—for example, *proximus*. Certainly less confusion exists by redefining the genus as having no inner mandibular tooth-series, thus excluding those species having an inner mandibular tooth-series. Were it possible to designate a new type of the genus and *proxima* were designated, then *Dermophis* and *Gymnopis* would become synonyms since *multiplicata* and *proxima* are congeneric, and a new generic designation would be necessary for the group of species having an eye (usually visible) not covered by bone and the single mandibular tooth-series. Other workers have not solved the problem of throwing the two genera together. If they have found forms that differ in the structures of the skulls

with relation to the eye, they have probably overlooked or disregarded the possibility that still another genus was involved.

It may be that *Gymnopis multiplicata oaxacae* with a visible eye, should be regarded a *Dermophis*. Dunn is somewhat ambiguous regarding the presence of the inner mandibular row of teeth. In his general discussion he says of the genus *Gymnopis* (combined *Dermophis* and *Gymnopis*) "the inner mandibular tooth row is poorly developed or absent (p. 441)". "In *Gymnopis* and in *Siphonops* the teeth on the lower jaw are *uniform* but larger than those on the upper. The inner mandibular row is reduced to one tooth on a side (in *oligozona* and in *multiplicata*) or is entirely absent." In the discussion of individual species he states: "Forms with visible eyes have on the whole, no teeth in the inner mandibular row." Under *Gymnopis multiplicata oaxacae* Dunn gives "inner mandibular teeth" as a character. One of the specimens listed by Dunn (EHT 16869) has no trace of the inner mandibular teeth. Mertens does not mention the character. Should it prove that others of the series referred to *oaxacae* have a visible eye not roofed by bone (as in EHT 16869) and lack the second series of mandibular teeth they should be referred to the genus *Dermophis* as a distinct species.

Dermophis parviceps Dunn

Siphonops parviceps Dunn, Occ. Papers. Boston Soc. Nat. Hist., vol. 5, July 9, 1924, pp. 93-94 (type locality, La Loma, Bocas del Toro Province, Panamá, elevation 1,200 ft. [not 2,000 ft. as originally stated]); Dunn, Proc. New England Zool. Club., vol. 10, Oct. 11, 1928, pp. 74-75.
Gymnopis parviceps Dunn, Bull. Mus. Comp. Zool. Harvard Col., vol. 91, no. 6, Dec. 1942, pp. 462, 478-479.

Diagnosis: Eye visible; lacking the inner mandibular teeth; primaries reduced, 96-97; secondaries 13-15; 5-10 complete; tentacle close to lip and nearer eye than nostril; ratio of diameter of body to total length, 21-24; probably under 200 mm. in length.

Description: (From KUMNH No. 36276, Moravia de Chirripó, Limón Province, Costa Rica). Head oval, slender, the width of head (5 mm.) at mouth angle, distinctly less than width of neck (7 mm.) or body (8 mm.); head length to first transverse nuchal groove (dorsally) 7.3 mm.; head to angle of mouth 4.5 mm.; width of body in total length (191 mm.), 21.3 times; tentacle close to lip, its distance from eye (1.25 mm.) less than its distance from nostril (2 mm.); distance between eye and nostril 3 mm.; snout extending beyond mouth 1 mm.; distance between eyes, 3.8 mm.; first nuchal groove passes across head then runs down and somewhat forward,

crossing the chin 6.2 mm. back from tip of snout; second groove crosses throat 3.3 mm. back of first; third groove separated on throat from second by 4 mm.; each of the annular folds, formed by the three grooves, with secondary grooves on dorsal surface only; on each side of the neck, beginning on back part of head, a longitudinal lateral fold limited above by a slight longitudinal groove, and extending back to near end of body, the ventral coloration covering the anterior part of fold. Palatal region rather short; maxillary-premaxillary tooth-series total 30; vomero-palatine series 28; mandibular teeth total 24; no inner mandibular (or splenial) teeth; outer mandibular teeth larger than maxillary or other teeth above; primary grooves 97; secondaries 14, with five of the latter complete; vent with a primary groove entering its sides, its anterior edge with two large lobules; a pair of narrow lateral lobules and five lobules bordering posterior part of vent.

Color in life: Above deep plumbeous lavender with some scattered irregular whitish spots or flecks, becoming lighter at the beginning of the lateral ridge; lighter grayish-lavender low on sides and venter; head pinkish flesh. In preservative head has become brownish gray, a slightly darker tone than the venter; ventral coloration limited by this lateral fold or ridge except for the first three annuli on the fold.

Measurements in mm.: Total length, 192 (180); snout to vent, 191; head width, 5 (5); width of neck, 7; width of body, 8 (8); head to first annular groove, dorsally, 7.3; head to angle of mouth, 4.5; width of body in total length, 21 times; tentacle from eye, 1.25; tentacle to nostril, 2; between eye and nostril, 3; length of snout beyond mouth, 1.1. (Measurements in parenthesis those given for the type.)

Dermophis occidentalis * sp. nov.

(Fig. 1.)

Type: KUMNH No. 36298, collected on the Dominical Road approximately 15 km. WSW of San Isidro del General in open meadow under stones, Aug. 3, 1954; Edward H. Taylor, coll.

Paratypes: KUMNH No. 36296, 36297, topotypes, taken July 19, 1952, same collector.

Diagnosis: A presumed diminutive species with secondaries 29-37; the primaries 112-113; secondaries completely surrounding body 10-12; length 186-204; body width in length 30-33.

* Latin, *occidentalis* = western.

FIG. 1. *Dermophis occidentalis* sp. nov. Type. KUMNH No. 36298, 15 km. WSW San Isidro del General, San José Province, Costa Rica. Total length, 186 mm.

Description of the type: Body slender, its width (5.9 mm.) contained in body length (186 mm.) 31.5 times; head narrow, oval, its width at mouth angle, 5 mm.; tentacle separated from mouth by .5 mm.; eye from mouth .92 mm.; nostril to eye 2 mm.; eye to tentacle .75 mm.; nostril from tentacle 1.5 mm.; snout projecting beyond mouth 1.1 mm. Snout to first annular groove 5.6 mm.; snout to third annular groove 10.5 mm., dorsal measurement (ventral measurement 10 mm.); primary annular grooves, 112 to vent, followed behind vent by an annular fold partly divided; secondary annuli, 28; secondary annuli completely surrounding body, 9; maxillary-premaxillary teeth (total) 26; vomero-palatine teeth 22 (total); outer mandibular series (total) 21; inner mandibular series absent. The vent is transverse, bordered anteriorly and posteriorly by several fleshy denticulations.

Scales are first found on the posterior part of the body along the primary groove following the beginning of the secondaries. At first the scales are small, forming short transverse rows wider than long (.4 x .9 mm.); they form a strongly overlapping series, usually only one row discernible at first; farther back the scales are much larger, arranged in at least three overlapping transverse rows in each annulus (posterior to the secondary groove and posterior to the primary groove a series of three or four similar transverse rows). These follow the grooves completely around the body. Seen in lateral view when one cuts through the skin, the scales of the back part of the preceding series overlap those of the following series, although they are separated by a series of recumbent glands which open near the groove.

Scales on the posterior part of the body are varied in size, but usually are considerably larger than those occurring anteriorly, some measuring 1.5 mm. x 1.3 mm. Some are cycloid or subcycloid but many of these are more or less truncate anteriorly.

Color in life: Head, on top and sides, light grayish tan; body plumbeous lavender; entire underside a lighter shade growing still lighter under neck; chin and throat lighter than top of head; area about vent dull cream.

Measurements in mm. and data on type and paratypes: Nos. 36298, 36296, 36297, respectively; total length, 186, 194, 204; width of body, 5.9, 6, 6.8; snout to first annular groove (dorsal), 5.6, 5.8, 5.7; snout to third annular groove (dorsal), 10.5, 10.6, 10.4; primary annular grooves, 112, 112, 112; secondary annular grooves, 28, 37, 33; complete secondary grooves, 9, 10, 12; maxillary-premaxillary

teeth (total), 26, 26, 26; vomero-palatine teeth (total), 22, 26, 26; outer mandibular teeth (total), 21, 21, 21; inner mandibular, 0, 0, 0.

Variation: The two paratypes agree well with the type. The eye is dim in No. 36296, but can be discerned at least on one side. The specimens were taken from under rocks or logs in a meadow. Two other species of caecilians occur in this same general area.

Dunn summarily states that "there are never more than two rows of scales or rings to a segment (in *Rhinatrema, Gymnopis* and *Caecilia*) and that there is no overlapping of the scales of one ring by those of another."

Nieden has mentioned that several rows may occur in an annulus and that overlapping may occur, both of which statements are true, at least in certain forms.

Dermophis costaricense * sp. nov.

(Fig. 2)

Type: KUMNH No. 36343. Collected, Cinchona, Heredia Province, Costa Rica, July 14, 1954, by Edward H. Taylor.

Paratypes: KUMNH Nos. 36337-36340, 36342, 36344-36347, all topotypes; July and August, 1954; Edward H. Taylor, coll; Nos. 36447-36448, Moravia de Chirripó, Limón Prov. Costa Rica.

Diagnosis: A *Dermophis* related to, but differing from *mexicanus* in having a higher average number of primaries 112-119 instead of 97 to 100; secondaries 80 to 93 instead of 51-80; total primaries and secondaries, 192-203 instead of 152-186.

Description of the type: Body not especially slender, its width (11 mm.) in total length (330 mm.) 30 times; head oval, its length from first annular groove 12 mm.; to third annular groove 22 mm. (dorsal measurement); when measured on ventral surface the measurements are 10 mm. and 20 mm. respectively; eye visible, not covered by bone, forming a slightly elevated mound, its distance from tip of snout 5.4 mm.; distance between eye and nostril 4 mm.; distance between edge of eye and tentacle 1.9 mm.; between tentacle and nostril 2.8 mm.; tentacle surrounded by a horseshoe-shaped groove, fastened behind to surface skin; angle of mouth to snout tip, 20.5 mm.; primary annular grooves (counting the three grooves of the first two modified annular folds) 113; secondaries (beginning on the 31st annular fold) 83; two partial annuli posterior to vent; first two modified folds each with a transverse groove which is to be interpreted as incomplete secondary folds, but which are not counted.

* Of Costa Rica.

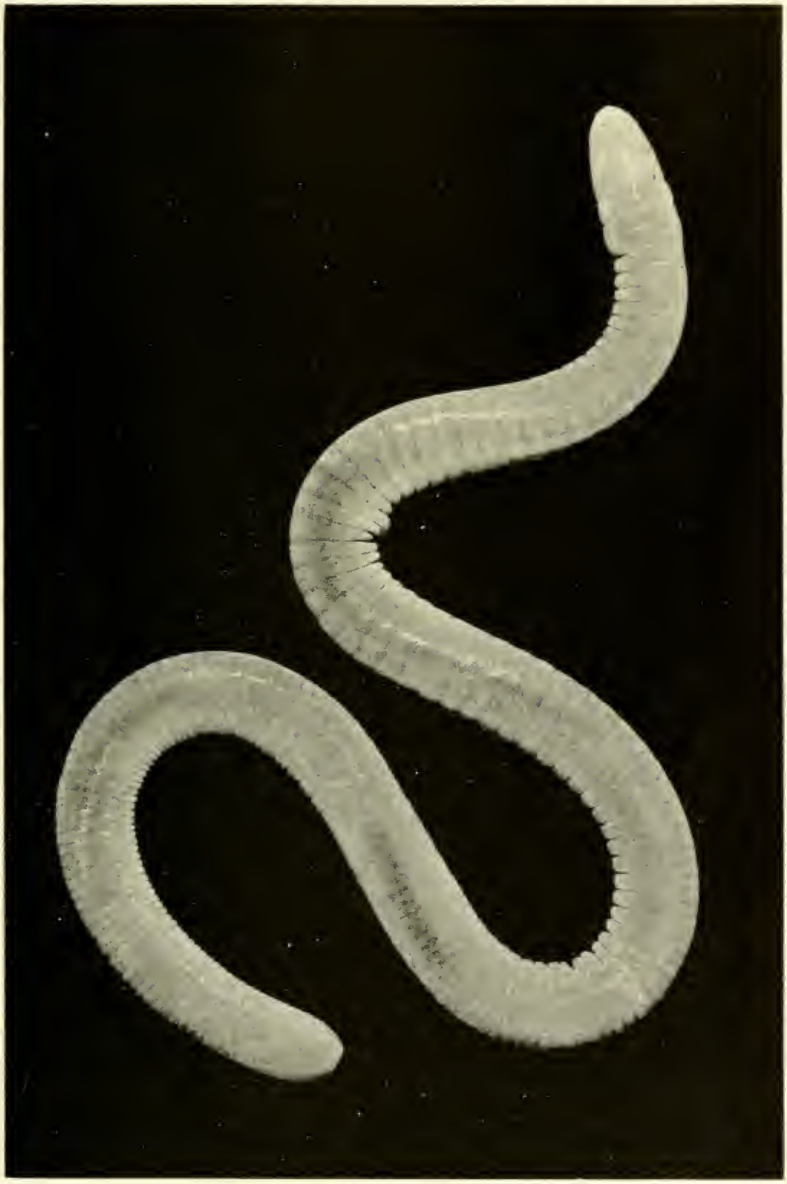

Fig. 2. *Dermophis costaricense* sp. nov. Type. KUMNH No. 36343, Cinchona, Heredia Province, Costa Rica. Actual total length 330 mm.

Scales begin as far forward as the 18th primary in the dorsolateral part of the annulus, and continue to the end of body, the transverse series growing longer posteriorly; in each annular fold there are four, sometimes five, rows of scales of varying size, contiguous or overlapping laterally, but each strongly overlapping the more posterior series. The scales usually present curved or rounding posterior edges, while the anterior edge is usually truncate.

The ventral surface of the body is more or less flattened, the posterior ventral region especially so; the vent shows two larger fleshy "denticulations" with a smaller median one; anterior to vent, laterally and posteriorly, there are 6 "denticulations," the surfaces of the "denticulations" showing a few indistinct papillae.

Maxillary-premaxillary teeth total 38, the maxillaries much larger than the premaxillaries; vomero-palatine series 38, much smaller than the premaxillaries; outer mandibular series 28, the teeth unequal in size, the largest double the size of the largest maxillaries; no inner mandibular tooth series.

Color in life: Above dark plumbeous, the head showing some lighter variegations; tentacular area and area about nostril lighter; ventral region somewhat lighter than dorsum; region of vent, cream; an indefinite lighter region under neck.

Measurements in mm.: Total length, 330; width of body, 11; width of head at mouth angle, 8.9; width of head at first annular fold, 9.1.

Variation: A series of paratypes from within a few hundred yards of the exact type locality shows some variation in the proportion of body width to body length, as well as certain variation in the number of primaries, secondaries and the number of complete secondaries.

The table on page 509 indicates much of this variation.

Remarks: This is not regarded as a subspecies of *mexicanus* since *Dermophis mexicanus* occurs from north central Veracruz to Panamá (*fide* Dunn) and *gracilior* a subspecies likewise in Panamá presumably shows closer relationship to *mexicanus* than does this species. Since *mexicanus* also occurs on the Caribbean drainage north of the Cordillera Central and on the eastern slopes of the Talamanca Mountains, it is probable that the two ranges overlap considerably. A specimen of *M. mexicanus* has been taken on the northeastern slope of Volcán Poás, within the probable range of this species.

Measurements and data on *Dermophis costaricense* sp. nov.

Number	Primaries	Secondaries	Complete secondaries	Maxillary, premaxillary teeth	Vomero-palatine	Mandibular	Inner mandibular	Length	Width	Width in length
36447	111	90	13	.....	.....	.....	0	387	15	26+
36343	113	83	12	38	38	28	0	330	11	30
36340	114	79	11	42	46	30	0	306	10.5	29+
36337	115	87	10	41	42	28	0	290	10.8	27—
36448	111	89	10	35	42	26	0	305	10.6	28+
36344	117	75	9	38	40	28	0	305	10.5	29+
36342	114	86	12	31	39	28	0	282	9	31—
36347	117	95	14	38	40	28	0	275	8	34+
36341	113	59	8	33	36	24	0	265	8.2	32
36338	113	93	11	35	37	24	0	260	8.8	30—
36346	115	88	9	32	38	26	0	212	9.8	27+
36345	113	81	9	32	37	26	0	195	7.6	26—
36339	113	83	8	30	32	24	0	170	6.7	27—

Nos. 36337-36347 Cinchona.
Nos. 36447-36448 Moravia de Chirripó.

Dermophis costaricense ranges in altitude from about 1,900 feet at Moravia to approximately 5,000 feet at Cinchona.

Dermophis glandulosus * sp. nov.

Dermophis mexicanus gracilior Taylor, Univ. Kansas Sci. Bull., vol. 34, pt. 2, Feb. 15, 1952, pp. 781-784, pl. 88.

Type: KUMNH No. 29979, San Isidro del General, San José Province, Virgil Cave collector.

Diagnosis: Eyes distinct, the tentacle closer to eye than nostril; 93 primaries (not counting nuchal grooves); 49 secondaries; no inner mandibular tooth-series; grooves throughout most of body showing a series of enlarged glands. Dorsum purplish lavender, somewhat darker on outer edges; lateral fold lighter lavender; ventral surfaces dull cream dimly clouded with lavender; 30 teeth in the maxillary-premaxillary series, the premaxillary teeth larger than others; prevomerine-palatine series total 40, the teeth small; outer mandibular row, 26, the teeth unequal in size. 22 of the 46 body secondaries encircle the body. Total length of type 159 mm.

This specimen was referred by Taylor to *Dermophis mexicanus gracilior* with some hesitation in the above cited work. Further study of this genus suggests that it is not *mexicanus* and is here given a different specific designation. Since the type was described at length in the above publication, it is not repeated here. The accompanying photograph shows something of the curious color pattern and the size and character of the enlarged annular series of glands.

* Latin, *glandulosus* = glandulose.

FIG. 3. *Dermophis glandulosus* sp. nov. Type, KUMNH No. 29979, San Isidro del General, San José Province, Costa Rica. Actual length, 159 mm.

GENUS GYMNOPIS Peters

Gymnopis Peters, Monatsb. Akad. Wiss. Berlin, 1874, p. 616 (type of genus *Gymnopis multiplicata* Peters).

The genus *Gymnopis* was proposed by Peters in 1874, with a very brief description and a single species *multiplicata* (which becomes the type) was described. The genus was described in 1879 as follows: "Augen unter den Schädelknochen gelegen Tentakelgrube etwas höher, sonst wie bei *Siphonops*, weit hinter dem Nasenloch gelegen, ringförmig das kugelförmige Tentaculum einschliessend. Körperhaut mit dachziegelförmig gelagerten Schup-

pen. Unterkieferzähne in zwei Reihen. Im Schädelbau *Siphonops* näher stehen."

Gymnopis multiplicata multiplicata Peters

Gymnopis multiplicata Peters, Monatsb. Akad. Wiss. Berlin, 1874, p. 616, pl. 1, fig. 1 (type locality, Veragua, Panamá).

The following specimens are in the collection, previously unreported: KUMNH No. 36667, 5 km. NE Tilarán, Guanacaste Province; No. 36668, San Isidro del General; No. 36670, 15 km. WSW San Isidro del General, Puntarenas Province?; Nos. 33669, 36671, 5 km. E (on highway) of San Isidro del General, San José Province.

In all the specimens the eyes are concealed under the bony surface of the skull, and the inner mandibular tooth row is present. Specimens from higher elevations have, on the average, fewer primaries (7-10) and a concomitant reduction in secondaries. Older, larger specimens (usually) have more teeth than young, smaller specimens, thus approaching the counts for *multiplicata proxima*—in fact, there seems to be an overlap in the count in certain specimens. The range of primaries in these specimens is 121-132, of secondaries 98-114, while in the specimens of *proxima* the range is 112-121, 87-102 respectively (see accompanying table of data and measurements).

Gymnopis multiplicata proxima (Cope)

Siphonops proximus Cope, Proc. Amer. Philos. Soc., vol. 17, 1877, p. 90 (type locality, eastern Costa Rica.) [=Limón, *fide* Dunn.]

The following specimens are in the collection: KUMNH No. 36675 Cariblanco, Limón Province; Nos. 36672, 36673, 36674, 36676, 36678 Turrialba, Cartago Province; No. 36677 Los Diamantes, Limón Province. The accompanying table shows much of the variation occurring in this series.

The scales in both subspecies usually appear six to eight folds in advance of the beginning of the secondaries. There are several transverse rows (three or four) of scales in each segment. These are contiguous transversely (or somewhat overlapping) and each row imbricates broadly with the following rows. The scales of one segment somewhat overlap those of the following segment in the posterior part of the body, but are separated by a row of elongated recumbent glands.

At birth, the maxillary-premaxillary tooth-series has appeared and 14 teeth are in evidence on each side. The vomerine and palatine teeth are differentiated. There are five or six palatine teeth protruding through the gums. Except for a large, median,

hooked tooth in the mid-line of the palate the vomerine teeth have not appeared above the gums. Subsequently this tooth is probably shed since a differentiated median tooth is not evident in older specimens. In the lower jaw the dentaries have four longer or shorter rows of teeth, irregularly disposed, perhaps 20-25 on each side; an inner mandibular series is not developed at this time. The dentary teeth of these juveniles do not resemble those of the adults. They are somewhat spatulate, each bearing several, fine, clawlike denticulations. A few of them have not yet risen above the surface of the gums but most of them are well above the surface. The two specimens showing this condition are RCT Nos. 331-332. One, 331, was taken in a small pile of rocks with a large adult specimen of *Gymnopis multiplicata proxima;* the other, No. 332, was in the uterus of the same adult specimen. These measure 129 and 125 millimeters respectively. The arrangement of the mandibular teeth is reminiscent of the condition obtaining in certain adult *Ambystoma—Ambystoma schmidti* and young *Ambystoma texanum.*

I find it difficult to account for the development of these special embryonic teeth. Two explanations are suggested: one that they represent a recapitulation of an ancestral condition, the other that they subserve some intra-uterine function.

The median hooked tooth on the vomer is not present in the intra-uterine specimen.

Gymnopis multiplicata multiplicata Peters

Number	Locality	Primary grooves	Secondary grooves	Complete secondary grooves	Teeth, maxillary-premaxillary	Teeth, vomero-palatine	Teeth, outer mandibular	Teeth, inner mandibular	Length	Width	Ratio L—W
36667	Tilarán.....	122	101	13	43	47	36	2	384	16	24
36668	San Isidro..	132	114	16	40	42	36	2	348	13	26.7
36669	5 km. E San Isidro..	121	98	8	38	44	33	2	323	9.8	32
36670	15 km. wsw San Isidro..	129	110	14	39	40	27	2	244	5.8	42
36671	5 km. E San Isidro..	122	102	10	30	30	24	2	148	4.8	31

Gymnopis multiplicata proxima (Cope)

36672	Turrialba...	118	96	12	40	48	36	2	394	16.8	23.5
36673	Turrialba...	118	95	9	50	54	38	2	391	17	23
36674	Turrialba...	112	87	9	42	48	34	2	360	18	20
36675	Cariblanco..	116	90	13	45	52	36	(?)	344	(19?)	29
36676	Turrialba...	119	93	10	39	38	30	2	279	13	21
36677	Los Diamantes..	121	102	11	34	34	26	2	216	7	31
36678	Turrialba...	116	97	10	33	32	22	2	179	7.8	22

SALIENTIA

Atelopus varius varius (Lichtenstein and von Martens)

(Fig. 4)

Phrynidium varium Lichtenstein and von Martens, Nomenclator Reptilium et amphibiorum Musei Zoologici Berolinensis, 1856, pp. 40, 41 (type locality, Veragoa = Veragua, Panamá).

This brilliantly colored *Atelopus,* black with markings of red and yellow above, was taken at several localities as follows (the first three localities are in the Caribbean, the last four in Pacific drainage areas): No. 32894, Moravia de Chirripó, Limón Province; No. 30299, a problematical specimen from Ujarrás or Navarro (M. T. Pacheco, coll.), No. 32885 Guabata, Mt. Paloma. Nos. 32863-32879, 15 to 20 kms. WSW of San Isidro del General; No. 32894, 4.5 km. E San Isidro del General, along highway; Nos. 32880-32883 near Sarchí, San José Province; Nos. 32886-32888 Palmar, Puntarenas Province. Two specimens, one, No. 32880, a large female from near Sarchí, and a male, No. 32866 from WSW of San Isidro del General are figured. All of the specimens from the Pacific drainage area, except one, agree in the general structural and color characteristics. Most of them are males and smaller than the females.

The dorsal colors are red or red-orange (rarely pinkish), with one or more mesial marks of bright yellow (rarely absent), and other reddish marks present on the limbs; the tips of the digits are yellow, the venter and chin light yellow-flesh, and an area on soles and palms somewhat orange-yellow. A few specimens have one or more small black ventral spots. Both lips are immaculate yellow and the area below the vent is colored like the venter.

The specimen from 4.5 kilometers east of San Isidro del General differs in having the dorsal markings very narrow, more numerous, and the venter has numerous, heavy, rounded or vermiculate marks on a yellow or pinkish-yellow venter. Both lips are blackish. The webbing on the feet is a little more extensive.

The specimens from the Caribbean drainage area do not agree among themselves and two may represent subspecific variants.

No. 32885 agrees in considerable detail with the Pacific group save that the lips are black and there are six rounded black spots on the venter.

No. 32894 has the venter unspotted save for three small spots on the breast and one on the chin. The lower lip is bordered with black and the upper has some dim black marks. The general color pattern shows the dorsal reddish marks narrowed and the middle

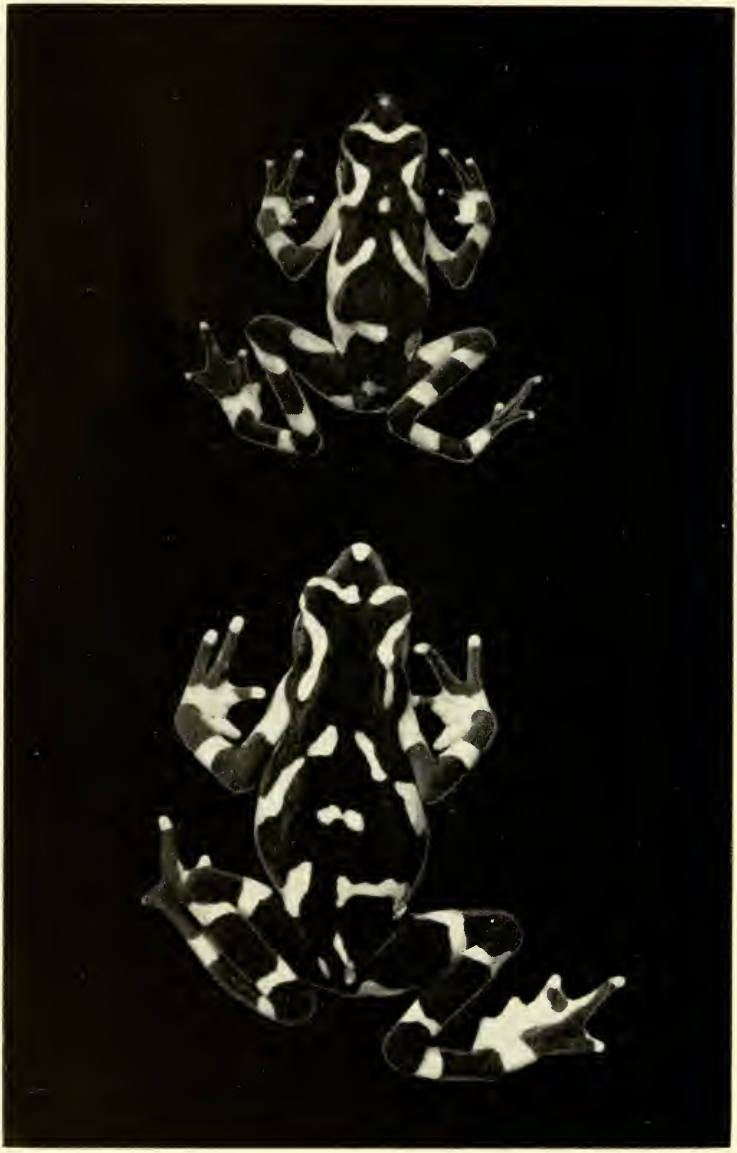

FIG. 4. *Atelopus varius varius* (Lichtenstein and von Martens). Upper fig. KUMNH No. 32866 ♂; snout to vent, 30 mm.; 15 km. SW San Isidro del General, San José Province. Lower figure, KUMNH No. 32880 ♀; length, 43 mm.; near Sarchí, San José Province.

of the back has numerous yellow dots. There is a large black area below the vent on the thighs.

No. 30299 may well represent a different form since the snout is more angulate and pointed, more flattened and projecting in profile. Much of the area under the thighs is black and four large rounded black spots are present.

This specimen from an uncertain locality (Ujarrás or Navarro) was collected by, and presented to me by Prof. Pacheco. No color notes were taken and I do not know what the color may have been in life. It is probably from an elevation higher than those I have collected. I suspect its relationship may be with *loomisi* and may represent it in the region where *varius* occurs.

Atelopus senex Taylor

(Fig. 5)

Atelopus senex Taylor, Univ. Kansas Sci. Bull., vol. 35, pt. 1, July 1, 1952, pp. 630-631 (type locality near the divide, between Volcán Poás and Volcán Barba, on western slope of Volcán Poás, Pacific drainage, elevation about 6,800 ft., Costa Rica).

Atelopus senex was described from a single specimen in the Richard Clark Taylor collection. In 1952 I acquired three specimens, KUMNH Nos. 32314-32316 from Guabata, Mt. Palomo, Costa Rica, collected by Prof. Marco Tulio Pacheco; and in 1954 another series of live specimens, KUMNH Nos. 35914-35922, from Navarro, Cartago Province, Costa Rica, presented to me by Prof. Pacheco.

The structural characters of these specimens agree well with those given for the type; however the color patterns differ much among themselves as well as from the color characters of the type.

The specimens have in common the following characteristics from which they differ from other known Costa Rican forms.

The skin on the head and most of the dorsal surface is smooth (lacking minute spicules, visible under magnification); the skin on snout (sometimes behind snout) shows one or more fine longitudinal grooves, none of which are in straight lines; the skin above the "supratympanic" ridge bears a paratoid thickening, cream white in color; the type and all of the specimens from Navarro have the venter dull gray with some indefinite lighter areas. However the three specimens from Guabata, Mt. Palomo, have the venter lighter with discrete black spots or flecks. The webbing on the feet reaches the terminal discs on all save the fourth toe and is not or but very slightly incised between. The three Guabata specimens are illustrated by a photograph showing the dorsal coloration.

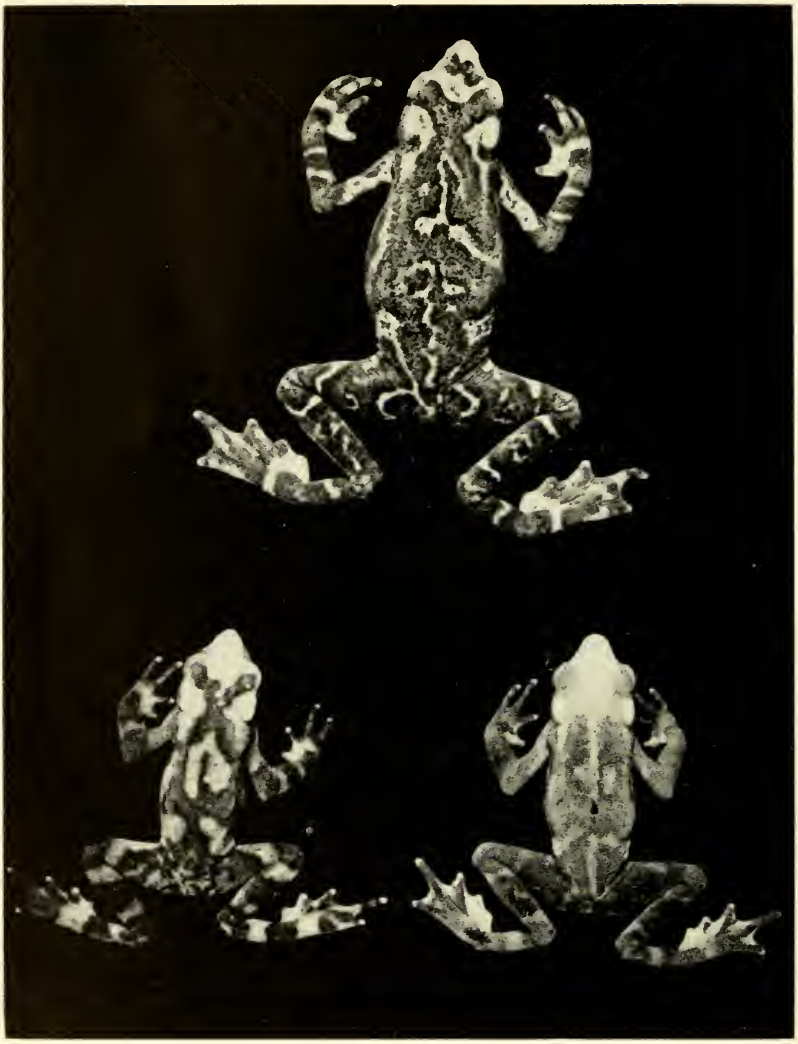

FIG. 5. *Atelopus senex* Taylor. Upper figure, KUMNH No. 32314 ♀, snout to vent length, 44 mm. Lower left figure, No. 32315 ♂, length, 32 mm. Lower right figure, No. 32316 ♂, length, 33 mm. All from Guabata, Mt. Palomo, Costa Rica.

The Navarro specimens are for the most part variegated, dark gray above, often with dim light lines following the sides (seen from above), and one along the anterior part of the median line; some have guanine flecks or spots, and one specimen (No. 35916) has the top and sides of the head, and almost all of the dorsum and sides

of body covered with large cream blotches; a few even appear on limbs. Another shows similar scattered spots and flecks only on head and shoulders. The guanine spots may be entirely lacking. The thickened (glandular?) area on the "supratympanic" ridge is invariably present and cream in color.

Atelopus loomisi Taylor

(Fig. 6)

Atelopus varius loomisi Taylor, Univ. Kansas Sci. Bull., vol 35, pt. 1, July 1, 1952, pp. 625-627, fig. 7 (type locality, Isla Bonita [Cinchona], eastern slope of Volcán Poás, Heredia Province, Costa Rica, approximately 5,000 ft. elevation).

This species has been traced north and down to an elevation of approximately 1,800 feet at Cariblanco, where two specimens were taken along the Saripiquí River. The lighter dorsal areas have a little more pigment than specimens taken at higher elevation. The venters, in life, had the same bright orange-red coloration and large black spots as did the type. Since more *Atelopus* from Costa Rica have been available for study I now regard this form a species distinct from *varius*. A problematical specimen occurring south of the Meseta Central of Costa Rica may represent a subspecies of this form. See comments under *Atelopus varius varius*.

The figure shows two of the typical series: KUMNH No. 24742, paratype, 41 mm.; type, No. 24744, 44 mm.

Eleutherodactylus mimus * sp. nov.

(Fig. 7)

Type: KUMNH No. 37128, 5 km. NNE Tilarán, Guanacaste Province, Costa Rica, Aug. 13, 1954; Edward H. Taylor, coll.

Paratypes: KUMNH Nos. 37126-37127; 37129-37132, topotypes, Aug. 13-15; same collector.

Diagnosis: In the *gollmeri* group (including *noblei*) but differing from *gollmeri* in having a slenderer head and body, and larger discs on fingers and toes. The first finger longer than second; a strongly defined, free-edged, inner tarsal fold about half the length of tarsus; toes at least two-fifths webbed (or somewhat more), the webs continuing as a strong fringe to the terminal discs; web reduced between the fourth and outer toe (less than one-fourth webbed); tympanum of male circular, a little more than three fourths of the diameter of eye; strong supratympanic fold continuing back in a slightly diagonal line, a branch from which goes behind tympanum.

* From Gr. mimikos=mimic.

FIG. 6. *Atelopus loomisi* Taylor. Upper figure, KUMNH No. 24742 ♀. Snout to vent length, 41 mm.; paratype. Lower figure, KUMNH No. 24744 ♀, paratype, snout to vent length, 44 mm. Both from Isla Bonita, Heredia Province, Costa Rica.

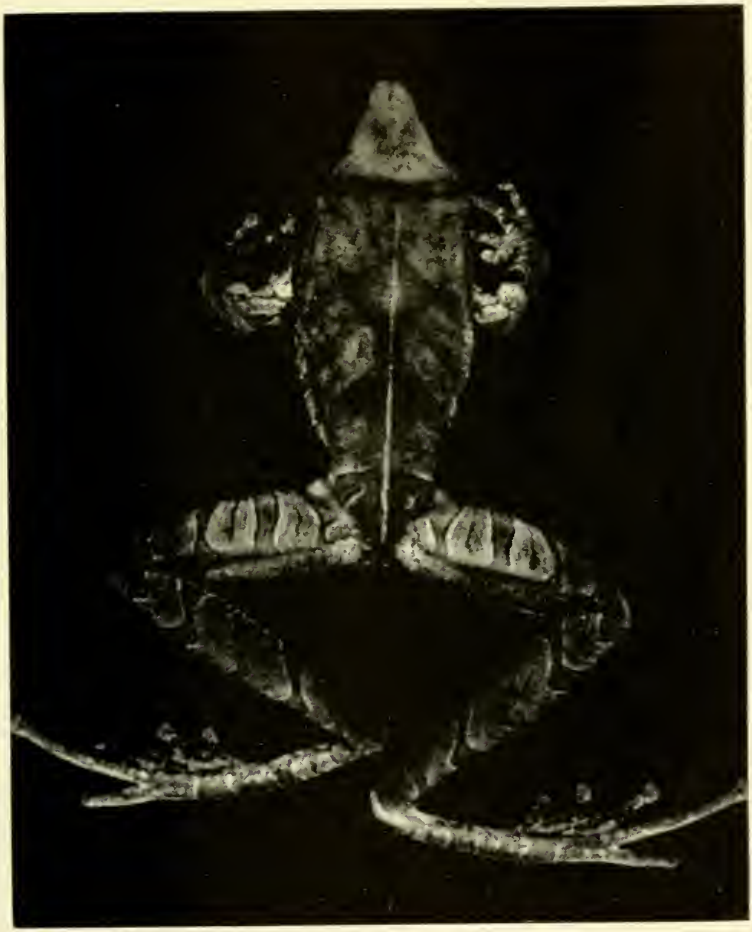

FIG. 7. *Eleutherodactylus mimus* sp. nov. KUMNH No. 37128, Type. Five km. NNE Tilarán, Las Cañas, Guanacaste, Costa Rica. Snout-vent length, 33.2 mm.

Description of species: Head slender, its length (18 mm.) much greater than its width (12.4 mm.); snout rather pointed, the tip rounded, the canthus distinct but slightly rounded; loreal region sloping precipitously,* not concave; a slight depression indicated between nostrils; head flat, except for a small ridge across the interorbital region; length of eye (4 mm.) equal to its distance from nostril; length of snout (median) 6 mm.; diameter of tympanum (3.15 mm.) at least equal to three fourths of eye length; distance

* The figure is somewhat misleading, since the dark sides of the upper jaws are not distinguishable from the background.

between eye and tympanum 1.5 mm.; snout projecting beyond mouth 1.2 mm.; tongue (7.5 mm. x 6.5 mm.) subcordiform, somewhat notched behind; choanae smaller than raised area of vomerine teeth, largely lateral; vomerine teeth behind, but within inner level of choanae, separated from choanae and each other by about the width of one series; no vocal slits or vocal sac; Eustachian tube openings much larger than choanae.

Arm brought forward, the wrist reaches tip of snout; first finger distinctly longer than second; subarticular tubercles large; three large distinct palmar tubercles, the median and outer may partially fuse; supernumerary tubercles on palm prominent; a lateral ridge on fingers scarcely discernible; terminal pads grooved transversely, outer pads a little wider than those on two inner digits, those on third and fourth a half wider than the adjoining part of finger. Leg long, the tibiotarsal articulation extending beyond tip of snout for a distance equal to one third of the tibial length; when legs are folded at right angles to the body they overlap 9.5 mm.; a sharp-edged, free, inner tarsal fold, half as long as tarsus; web reaching to middle of first finger, two thirds the length of the second and third, about one fourth the length of outer finger; discs on toes larger than those on fingers; a broad fringe on both sides of toes to disc which is wider than digit with fringe; no tubercles on sole; an elongate inner metatarsal tubercle and a much smaller rounded outer one.

Skin on much of dorsal surface smooth; two pairs of moderately distinct tubercles in shoulder region, the outer a little the larger, inner a little farther forward than outer; a strong supratympanic fold runs diagonally back from eye and continues as a free fold of skin along the sides; a pair of low tubercles behind lower edge of tympanum; a strong posttympanic fold branches from the supratympanic fold and runs down closely behind the tympanum; sides with a few minute granules; venter and chin smooth; a ventral disc limited by distinct folds laterally and posteriorly; posterior lumbar region finely granular, with larger granulations in region of vent and below it; granules present on inner part of the under side of thighs.

Color in life: Above generally dark lavender-brown; the snout to middle of interorbital region clay-white, bordered behind by a straight, narrow black line; a hair-fine median cream line, not reaching tip of snout; a dim, darker, symmetrical, dorsal pattern consisting of a diamond-shaped figure with radiating lines and a lighter center, greatly narrowed in the middle of back, then sud-

denly widened, sending two branches back diagonally; some transverse marking on back of lumbar region; side of head and tympanic area dark lavender, the color continuing on side to near venter; edge of lip a little lighter; venter and breast flesh-white; throat and chin with a scattered powdering of blackish pigment; an area under thighs and tibia pinkish. Thighs above with at least four irregular brown bars with lighter edges, separated by grayish lavender which may have narrow secondary bars; tibia with four or five, more or less chevron-shaped bands with lighter edges; tarsus and foot with indications of bars; an irregular brownish-black area at knee continued as a blackish stripe on front of tibia; sole purplish; top of foot and digits flecked with darker; palm much lighter than sole; black spots on front of arm; a dark arch about region of vent; back of thigh uniform light brown.

Measurements in mm.: Snout to vent, 33.2; width of head, 12.4; length of head, 18; arm, 17; leg, 65; tibia, 13; tarsus and foot, 27.

Variation: The general color pattern can be discerned in the paratypes if they are submerged in clear liquid but the colors on the whole are less intense in the younger specimens. One specimen has three light rounded spots on the middle of the back arranged in triangular pattern. Some of the specimens have a pair of small tubercles on the dorsal surface of the snout and the dorsal surface of the body is slightly more shagreened. The surface of the thigh and tibia also may show very fine granulations. The transverse interorbital fold, the character of the webbing of the digits, the size of the digital discs, are constant. The median light line rarely reaches the top of the head. The lateral skinfold may not always be in evidence. The females have smaller tympani that are higher than wide.

Remarks: At this type locality a specimen of *Eleutherodactylus noblei* was taken, but the related *Eleutherodactylus gollmeri* was not found. I have examined the types of *Lithodytes lanciformis* Cope. The head is much wider (9.8 mm. x 11 mm.). It is not impossible that *lanciformis* is identical with *noblei* but the present condition of the types makes it impossible to be certain. The pinkish coloration mentioned by Cope is characteristic of young specimens of *noblei.*

In the U.S. National Museum I have examined a specimen of this new species (number and locality not recorded by me) having a snout-vent length of 43.5 mm., arm, 22; leg, 88; tibia, 31.6; foot and tarsus, 37; heel extending beyond snout 13.5 mm. It is identified as *lanciformis.*

Eleutherodactylus vocator * sp. nov.

(Fig. 8)

Type: KUMNH No. 37001, Agua Buena, Puntarenas Province, Costa Rica, July 25, 1954, Edward H. Taylor, collector.

Paratypes: KUMNH Nos. 36999, 37000, topotypes, same collector, July 24, 1954.

Diagnosis: A diminutive frog, the head much narrower than the body; maximum known size, ♀ 17.6 millimeters; first finger distinctly shorter than second, lacking webs on both hands and feet; digital discs small on outer fingers, that on first not wider than digit and those on inner toes are not perceptibly wider than digits, while the third and fourth have discs slightly wider than adjoining part of digits and pointed rather than rounded terminally; heel reaches to eye; interorbital distance a half wider than an eyelid; a

FIG. 8. *Eleutherodactylus vocator* sp. nov. Type and paratype. Figure on left, KUMNH No. 37000 ♂, paratype, Agua Buena, Puntarenas Province; figure on right, KUMNH No. 37001 ♂, type, Agua Buena, Puntarenas Province, Costa Rica, snout-vent length, 16.2 mm.

strong notch at median point of upper lip. Male with a very ample vocal pouch, the vocal slits extending back beyond mouth angle; vomerine teeth absent; the choanae lateral, concealed when seen directly from below; venter smooth, and pigmented.

* From Latin, *vocator* = one who calls.

Description of type: Head relatively small, the snout pointed (seen from above) and flattened, since the line of the mouth tends to curve up anteriorly; canthus rostralis moderately distinct, rounded; the loreal region sloping very abruptly (nearly vertical) and not concave; nostril well back from the snout tip, the distance from eye (1.2 mm) a little greater than its distance from median point on upper lip (1.16 mm.); length of eye (2.1 mm.) shorter than length of snout (median measurement 2 mm.) but less than its distance from the median point on tip measured laterally (2.45 mm.); tympanum covered with pigmented skin, the anterior outline visible, its greatest diameter .55 mm.; an indistinct fold from eye runs diagonally back covering a portion of tympanum; interorbital distance (2.35 mm.) much wider than eyelid (1.5 mm.); a strongly distensible, subgular, vocal sac which forms two strong plies when not distended; tongue much narrowed in its anterior half, then widening, its greatest length more than double its greatest width; vocal slits elongate, running back behind angle of mouth; choanae lateral, hidden when palate is seen from below; vomerine teeth absent; openings of Eustachian tubes no larger than choanae; a distinct notch in median point of upper lip; snout extending beyond line of mouth .6 mm.

Arm brought forward the wrist reaches to tip of snout; first finger much shorter than second without a widened disc, the length 1 mm.; disc on third finger pointed anteriorly; on other fingers the discs are not or but minutely wider than adjoining part of digit; subarticular tubercles flat; two palmar tubercles somewhat indistinct, the outer (median) large, subcircular.

Leg short, when folded at right angles to body heels fail to meet by one millimeter; leg brought forward, the tibiotarsal articulation reaches to near middle of eye; no trace of a tarsal fold; discs on digits not or a trifle wider than the digits, that on the fourth toe pointed and somewhat asymmetrical; subarticular tubercles flat, indistinct; some evidence of supernumerary tubercles on palm and sole; a low, rather large, inner, metatarsal tubercle, its outline not strongly defined, the outer distinct, somewhat more elevated.

Skin on dorsal part of body and head finely shagreened (seen under a lens); sides of abdomen with some granulation extending to venter; posterior part of venter with some very flat granules; posterior and part of ventral surface of thighs with relatively large, strong granules; skin of throat smooth, but distended; a pair of

tubercles below and behind tympanum and one preceding it. No ventral abdominal disc.

Color: Gray above with a narrow interorbital darker line and an elongate indefinite darker median area; a white spot on heel; on each side of the chin a lighter area. Entire ventral surface and concealed parts of the limbs pigmented, the pigment forming a reticulation leaving very numerous small rounded light areas; this likewise true of the sides of body; lips with several indefinite light flecks; a dark line follows the supratympanic fold; a light spot at (dorsal) base of each digital disc. Underside of hands and feet pigmented.

Measurements of type and paratypes 37001, 37000, 36999, respectively: Snout to vent, 16.2, 16.1, 17.6; width of head at jaw angle, 6, 6, 6.1; length of head, 7, 6.9, 7; arm, 8.6, 8.5, 9; leg, 23, 22, 23; tibia, 7.6, 7.2, 7.3; hand, 3.3, 3.1, 3.25; tarsus and foot, 10, 10, 9.9.

Variation: The male paratype agrees very closely in size as well as in other characteristics with the type, save that the dorsal pigment, and some of the lateral, tends to form dark flecks. A somewhat diagonal, lighter line follows below the diagonal dark line marking the supratympanic fold. The female paratype is dark, appearing nearly black on head and shoulders. However lighter flecking occurs on the sides, rump, and to some extent on limbs. Lateral light areas are present on sides of the chin and the white flecks on the darker venter are more conspicuous, as is the heel-spot. The female, as well as the males, is adult and the abdomen is distended with four, large, yellowish eggs.

Remarks: A related species *Eleutherodactylus diastema* was described from a specimen taken by John M. Bransford on the Panamanian (not Nicaraguan) Canal Survey of 1874. The exact locality is given as "Camp Mary Caretta" but a manuscript label is said actually to read Camp Margharetta, and the suggestion has been made that Margarita, near Colón, is intended. In the specimens I have identified as belonging to Cope's *Lithodytes diastema,* the adult males and females are considerably larger than males or females of this species. The female of *diastema* may lay as many as ten eggs measuring four millimeters in diameter. The yolk of the egg is cream completely lacking in dark pigment. At Cervantes, Cartago Province, this species has been taken chiefly in bromelias at about 4,800 ft. elevation. Here the species is common, some plants yielding half a dozen specimens, all showing considerable variation in color and marking. The eggs of that

species are frequently found in the bromelias. These are usually laid so they are not submerged, the young having a direct transformation typical of most, if not all, Costa Rican *Eleutherodactylus*. Several females may lay their eggs together in a single plant, and at different times, since sets, differing in degree of development, may be found side by side.

Noble (1918) also described a form from Nicaragua under the name of *Hyla chica*. He considered that the clawlike terminal phalanges placed the frog in the family Hylidae. However the life history involving the absence of a free swimming stage (as well as other considerations) seem certainly to place his form in *Eleutherodactylus*. I have not examined the type but consider it likely, that, if not a definitive form, it belongs with *diastema* rather than with *vocator*.

The most outstanding differences between *vocator* and *diastema* are that the former has smaller, differently shaped, terminal digital discs, and the head is more pointed, and presumably the species fails to attain as large a size. The species probably occupies the Pacific slopes of the Talamanca Range, and the Brunqueña Mountains. Many were heard at Agua Buena and presumably also in the mountains above San Isidro del General but no specimens were found in the latter locality. In northern Costa Rica along the Pacific slopes of the Cordillera Volcanica they were neither heard nor seen.

Eleutherodactylus diastema (Cope)

(Fig. 9)

Lithodytes diastema Cope, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 8, 1876 (1875), pp. 153-156 (type locality "Camp Mary Caretta," Panamá).

This species was not figured in my paper, "A Review of the Frogs and Toads of Costa Rica" (Univ. Kansas Sci. Bull., vol. 35, pt. 1, 1952, pp. 701-703) hence I am presenting here a photograph of four specimens to show color-pattern variation. This may serve as a basis of comparison with the figure of *Eleutherodactylus vocator* herein described.

GENUS AGALYCHNIS Cope

Agalychnis Cope, Proc. Acad. Nat. Sci. Philadelphia, 1864 (Aug. 30), p. 181 (type of genus *Hyla callidryas* Cope)*; *idem*, p. 182; Nat. Hist. Rev., 1865, pp. 110 (embraces *H. moreletii, H. holochlora* and *H. callidryas*).

On the night of Aug. 14, 1943, a large pond was visited at a point some 4 kilometers NNE of Tilarán. Large numbers of amphibians

* Taylor, Univ. of Kansas Sci. Bull., vol. 35, pt. 1, 1952, p. 801, incorrectly states that *Hyla moreletii* is the type of genus.

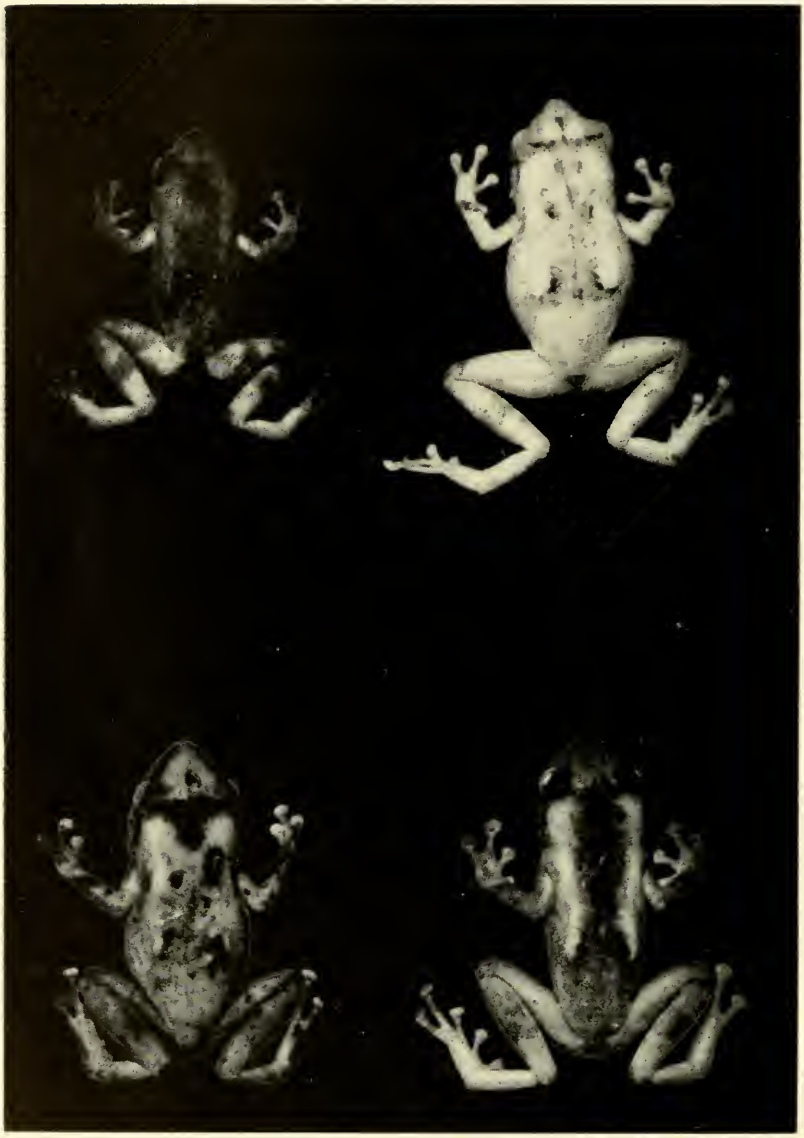

FIG. 9. *Eleutherodactylus diastema* Cope. Upper left, KUMNH No. 31643 ♂, snout to vent length, 19 mm.; upper right, No. 31633 ♀, length, 22.2 mm.; lower left, No. 31672 ♀, length, 24 mm.; lower right, No. 31629 ♀, length, 24 mm. All from Cervantes, Cartago Province, Costa Rica.

composed of several species were calling from the shores or from weeds partly submerged and together their voices blended into a great chorus. Several were found breeding. In the weeds partly covered with water and in trees and shrubs along the edge of the pond very large numbers of breeding *Agalychnis callidryas* were found—the number of males seemingly exceeding the number of females. Near one end of the pond (approximately 200 meters in length), a second but smaller species of *Agalychnis* was found, these seemingly occurring in smaller numbers and it was presumed that these were not breeding. Ten adult males and one female were collected and several young that were partially or completely transformed. Certain young and one adult male were found on plants and shrubs three hundred meters from the pond and perhaps a hundred meters higher than the pond level. In contrast more than fifty adult *callidryas* were collected at the pond and a much larger number could have been acquired with ease. Many of these were clasping and eggs were found on leaves above the water. No young specimens or larvae of this species were taken.

The smaller species belongs in the section of the genus that includes *dacnicolor, alcorni,* and *moreletii,* the latter of which also occurs in Costa Rica. However the species is distinct, and I believe, unnamed. It is described below.

Agalychnis saltator * sp. nov.

(Fig. 10)

Type: KUMNH No. 35615, 4 km. NNE of Tilarán, Guanacaste, Costa Rica, Edward H. Taylor, collector.

Paratypes: 35609-14; 35616-26. Topotypes. Prof. Marco Tulio Pacheco, Srta. Georgiana Pacheco and Edward H. Taylor, collectors.

Diagnosis: A small species, the largest male 44 mm., the single female 52 mm.; eye reddish; body lacking lateral black and cream markings; width of interorbital region equal to, or minutely greater than, width of an eyelid; canthus rostralis indicated but rounded; no paratoid; digits less than half webbed on feet, less than one third webbed on hand; skin-fold above tympanum obsolete but very strong behind tympanum, continuing above arm; heel to front of eye; tympanum very distinct, its diameter slightly less than half length of eye; green above with narrow, dim, wavy, darker, transverse lines indicated on body; a cream spot at posterior corner of eye.

* Latin, *saltator* = leaper.

FIG. 10. *Agalychnis saltator* sp. nov. Type. KUMNH No. 35615, four km. NNE Tilarán, Guanacaste, Costa Rica. Snout vent length, 44 mm. (transverse dark lines, visible to the eye, are scarcely shown in the photograph).

Description of type: Head triangular, wider than the body; no paratoid present; canthus indicated, curving forward, rounded; areas about nostrils swollen with a slight depression between; in profile, snout sloping down to edge of lip; distance between eye and nostril (4 mm.), greater than distance between nostril and median notch on upper lip (3.2 mm.); loreal region sloping

broadly to lip, not or but slightly concave; narrowest interorbital distance (4.3 mm.) greater than an eyelid (4.1 mm. flattened); tympanum circular, its diameter (2.4 mm.) less than half length of eye-opening (5.2 mm.); eye to tip of snout 5.3 mm. (median measurement); upper eyelid folds down somewhat over eyeball; lower lid with cream venation; large vocal slits in floor of mouth extending but little forward of the mouth angle; tongue longer than wide, notched behind, free for nearly half its length and free on sides; choanae large, the vomerine teeth in two tiny fascicles, between the anterior borders of choanae, separated from each other by a distance equal to one fascicle and from edge of the laterally placed choanae by a somewhat greater distance; openings of the palatal glands form an indefinite line nearer tip of palate than anterior level of choanae; upper arm slender, pigmented above, forearm thickened with a prominent "elbow"; a cream skinfold beginning behind elbow runs along outer ventral surface of arm and is more or less evident to base of outer finger; first finger much shorter than second, the disc widened, a little smaller than tympanum; discs on two outer fingers a little larger than second, and double width of first; web between first two fingers short, failing to reach to level of the subarticular tubercle of first and not half way to tubercle on second finger; between second and third to upper level of tubercle on second, to base of tubercle on third; between two outer fingers web reaches half way to tubercles—all webs continuing to discs as a thick fringe; tubercles on two outer fingers bifid; palmar tubercles not strongly defined, that at base of first finger flat, oval; two small tubercles on palm; well-defined supernumerary tubercles; first finger on inner dorsal surface with a patch of small brownish nuptial spines; leg relatively short, the heel reaching front edge of eye or slightly farther; when legs are placed at right angles to body, heels overlap three millimeters; tarsal fold very indistinct save for an irregular row of minute granules; outer fold barely indicated by a white line; first toe shorter than second; two inner toes less than a third webbed; between second and third, web reaches to middle of distal tubercle of second toe; between third and fourth, web reaches to base of distal tubercle of third and between two outer toes to about the same distance; webs continued to discs as a fringe; discs on toes smaller than those on second finger; inner metatarsal tubercle narrow, elongate, outer farther forward, distinct, small; subarticular tubercles and supernumerary tubercles present.

Skin on dorsum, head, and above thighs with small granules or corrugations, not equally distributed, but very distinct especially on sides of head; tympanum somewhat elevated, thinly covered with skin; back edge of tibia rather sharp; region of vent sticking out behind level of thighs, the skin flap covering the vent does not reach down quite to level of vent; on chin, skin wrinkled but without distinct granulation; venter strongly granular; inner part of thigh with small granules intermixed with larger granules, the latter forming an indistinct row on posterior edge; the skinfold from eye is obsolete above tympanum or dimly indicated, prominent behind tympanum.

Color in life: Above dark leaf-green with dim indications of transverse, darker, wavy lines or spots on dorsum; ventral and concealed surfaces of limbs, yellow orange. The green color covers only outer finger and part of two outer toes; front and back of thigh and part of upper arm lavender, the green color forming a narrow line on top of thigh. Area about vent somewhat whitish; a cream-white spot at back corner of eye; eye reddish.

Measurements in mm. of type and No. 35622 ♀ : Snout to vent, 44, 52; width of head, 15, 17; length of head, 15.2, 18; arm, 29, 34; hand, 13, 14; leg, 68, 78; tibia, 22, 25.4; foot and tarsus, 28, 33.

Variation: When first taken all the adults were of practically the same shade of green and orange. In preservation part of the specimens have become brownish or brownish lavender with a frosting of bluish white over the dorsal surfaces. The darker transverse markings can be seen below this color, and in No. 35625 the markings are rather clearly defined. The orange coloration is lost leaving these pigmentless surfaces white.

Relationship: The relationship, based on the absence of lateral cream and purple markings, is seemingly with *Agalychnis moreletii*. The latter species is much larger (nearly 25 percent in linear measurement and more than double the volume). The skin is smoother, and the supratympanic fold well developed above tympanum; the tympanum is less well defined and the webbing on fingers and toes is greater. The vent opens downward at level of venter.

Remarks: Besides the series of *Agalychnis saltator*, the following species of amphibians were taken at the pond on the same evening: *Smilisca baudini, Hyla underwoodi, Hyla loquax, Hyla ebraccata, Bufo coccifer, Hyla phaeota, Agalychnis callidryas, Leptodactylus melanonotus.*

REPTILIA

Genus Eumeces Weigmann

Eumeces Wiegmann, Herpetologia Mexicana, 1834, p. 36 (type of genus *Scincus pavimentatus* = *schneideri*).

This cosmopolitan genus occurs in the Western Hemisphere from Canada throughout most of the United States and Mexico, and into Central America but the number of species dwindles until only three are known south of the Isthmus of Tehuantepec. Two of these extend into northern Central America, *Eumeces schwartzi* having been taken in northern Guatemala and *E. sumichrasti* in northern Honduras. The third species, originally discovered in Managua, Nicaragua, is here traced south into Costa Rica and presumably it is the only known species of the genus occurring there. Four specimens were taken.

Eumeces managuae Dunn

(Fig. 11)

Eumeces taeniolatus (*non* Blyth) Boulenger, Catalogue of the lizards in the British Museum, vol. 3, 1887, p. 383 (type locality [*in errore*] "Punjab, India").

Eumeces managuae Dunn, Proc. Biol. Soc. Washington, vol. 46, 1933, p. 67, 68 (type locality, aviation field Managua, Nicaragua); Taylor, Univ. Kansas Sci. Bull., vol. 23, pp. 104-110, pl. 3, figs. 6, 7, 8.

Diagnosis: A large species of the genus characterized by a greatly expanded series of median dorsal scutes; four pairs of expanded nuchals, one postmental, a postnasal; large auricular lobules; subcaudals transversely widened; adpressed limbs widely separated; gray or gray-brown above, the dark color tending to form elongate lines.

Description of species. (From KUMNH No. 34185, Tenorio, Guanacaste, Costa Rica). Rostral large, much wider than high, the part visible above forming a very obtuse angle, its length less than that of the supranasals; latter moderate, broader than long, the length of the median suture distinctly less than the greatest length of the scale, which is less than its width; the nasal is definitely divided; frontonasal much larger than the prefrontals, wider than long, forming a suture with the frontal and at same time separating the prefrontals; latter generally pentagonal, touching two loreals laterally, and touching the frontonasal, frontal, first supraocular, and first superciliary; frontal angular anteriorly reaching its greatest width between the first supraoculars, and then narrowing slightly posteriorly, bounded laterally by two supraoculars and behind by the paired frontoparietals, and not making a suture with the interparietal (as in the type). Interparietals a

FIG. 11. *Eumeces managuae* Dunn. KUMNH No. 34185, Tenorio, Las Cañas, Guanacaste, Costa Rica. Total length, 282 mm.

little smaller than the prefrontals (much smaller in the type) their mutual suture about one third of their length, and touching three supraoculars laterally; parietals not separated by the interparietal, their posterior inner edges forming a suture; four pairs of widened nuchal scales; a postnasal present behind the posterior nasal; two loreals, the anterior higher and much widened at top, and generally slenderer than posterior; four supraoculars, the second largest; three well-defined presuboculars, eight superciliaries, three or four small preocular scales, one touching the loreal; four postsuboculars; primary temporal small, quadrangular; secondary temporals large, the upper elongate, the lower triangular; tertiary temporal present. Seven supralabials followed by two superimposed pairs of postlabials. About 27 irregular scales about ear-opening, three of the anterior scales form lobules; five supralabials preceding the subocular supralabial; mental bordering mouth a somewhat longer distance than rostral, nearly twice as wide as deep; seven infralabials; a single postmental followed by three pairs of chinshields, only the first pair forming a median suture; scales on dorsum from parietal to above vent, 67, of which four are nuchals, followed by seven large paired scales, and these in turn followed by 56 widened body scales; scales about anterior part of neck, 31; about narrow part of neck, 23; about middle of body, 17; about axillary region, 26; about base of tail, 13. A total of 83 subcaudals, all about five times as wide as long except two pairs following the vent (the distal part of the tail is regenerated); a tiny patch of granular scales in axilla and a similar elongate patch behind leg insertion.

Third and fourth fingers equal in length, each with twelve scales on under surface; palm with three light padlike scales larger than others; fourth toe distinctly longer than third with sixteen keeled scales below; three large padlike scales on heel.

Color: Above rather yellowish brown, the head somewhat lighter, rather more grayish brown on sides; a light lemon-yellow wash

Measurements of *Eumeces managuae* Dunn

Number	34185	34186	34187	34188
Sex	♂	♂	yg	yg
Snout to vent	125	104.5	62	57
Tail	157	145.5	30 reg.	41 broken
Snout to eye	8	7.2	4.8	4.4
Snout to foreleg	36.5	32	20	20.2
Axilla to groin	74	60	36.5	33
Arm	22	22	13	12
Leg	30	27	16	15
Width of body	19	16.5	11	9
Width of head	16	14	9	8.5

on venter; chin whitish; the dorsal scales with one or two darker areas that form discontinuous darker lines, two median, and one each on other scale rows; chinshields and six ventral rows immaculate flesh with dark flecks appearing at base of tail and growing more numerous toward tip; each labial with a dark spot; each head scale with a darker mark, some with more than one.

Variation: Nos. 34186 and 34187 have the frontoparietals separated instead of forming a suture, while 34189 has them touching at a single point.

In the two young specimens the outer ventral scale rows may have some dark flecks. The general color above is wood-brown with the dark lineation strong and continuous. In the younger specimen the yellow of the venter is more pronounced. It is remarkable that these specimens were collected on an airfield as was the type.

They were found burrowing under the edges of small boulders and two were taken from a small pile of stones. Certain others seen escaped into masses of growing cacti about rocks. This is the southernmost record of the genus *Eumeces* in the Western Hemisphere.

GENUS ANADIA Gray

Anadia Gray, Catalogue of the specimens of lizards in the collection of the British Museum, 1845, p. 74 (type of the genus, *Anadia ocellata* Gray).

Diagnosis: Slender, elongate lizards, the head narrowed and rather pointed. Head with regular shields; frontonasal present separating nasals; nostril in a single nasal, or in a suture between two nasals; eyelids developed, with a divided transparent disk on lower lid; scales smooth, juxtaposed, or slightly imbricate, forming transverse rows; ventrals equal to or a little larger than dorsals, quadrangular, forming transverse and longitudinal series. Tail cylindrical; lateral teeth compressed, tricuspid; tongue bifid, somewhat arrow-shaped; auricular opening present; limbs rather weak, pentadactyl. At least some forms are arboreal.

This genus comprises some nine or ten species distributed chiefly in northern South America. Only a single species is known in Central America. This was described in 1875 by E. D. Cope as *Chalcidolepis metallicus* from a single specimen collected by William Gabb in the Aguacate Mountains of Costa Rica. Later Cope (1885) placed his *Chalcidolepis metallicus* in the genus *Leposoma.*

The genus was reviewed by Arthur Loveridge in 1929, and a new species, *Anadia nicefori,* was described from Colombia. In the same paper he reports another specimen of Cope's species from Costa Rica.

Burt and Burt in 1933 again list the South American species of the genus. Dunn, in 1944, reviewed the Colombian species, describing a new form, and listing, in all, six species for Colombia. He places *Anadia nicefori* in the genus *Ptychoglossus*.

To the best of my knowledge the genus is still unreported in Panamá. The Costa Rican material of the genus has been scant. Mr. Loveridge has loaned me two Costa Rican specimens from the Harvard collection. There are three in my Costa Rican collections.

KEY TO FORMS OF ANADIA IN COSTA RICA

1. Femoral pores, 3-?; 23 scales about body; 56 transverse dorsal rows between parietal and back level of thigh; brown above with a row of blackish scales on each side ..... *metallica metallica* (Cope)
   Femoral pores, 5 or more; more than 25 scales around body 2
2. Femoral pores, 5-5; 28 scales about body; 63 transverse scale rows between parietals and back level of thighs; back heavily spotted with black ..... *metallica arborea* subsp. nov.
   Femoral pores, 9-10; 28-31 scales about body; 52-56 scales between parietal and back level of thighs; black spotting on back reduced or absent ..... *metallica attenuata* subsp. nov.

The material is inadequate to determine positively whether we are dealing with species or subspecies. One may presume that *metallica* occupies the Pacific drainage of the Aguacate mountains and perhaps also of the adjoining Talamanca Range; *arborea* the Pacific slopes of the Cordillera Volcanica; and *attenuata* the Caribbean drainage of the Meseta Central and the eastern slopes of the Talamanca Range. It may be doubted that the barriers are such as to bring about complete isolation. An accumulation of series from a given locality will permit one to determine the extent of variation and a clearer interpretation of the relationships as to whether they are specific or subspecific.

One other fact suggesting the closer relationship is that the light color on the side of neck and upper lip (including lower eyelid) seemingly is nearly identical in the three forms, and at least in two there is a row of widely spaced light dots from above arm insertion to the groin, some of which may have dark borders. However, this condition obtains also in certain species occurring in South America.

Anadia metallica metallica (Cope) (new combination)

Chalcidolepis metallicus Cope, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 8, 1876 (1875), pp. 116-117, pl. 24, fig. 5; pl. 28, fig. 2 (type locality, "Aguacate Mountains," Costa Rica, William Gabb, coll.).

Ecpleopus (*Chalcidolepis*) *metallicus* Bocourt, Mission Scientifique au Mexique et dans l'Amérique Centrale; Étude sur les Reptiles et les Batraciens, livr. 6, 1879, pp. 371-372.

Leposoma metallicum Cope, Proc. Amer. Philos. Soc., vol. 23, no. 121, Jan. 1886, pp. 97-98; U. S. Nat. Mus. Bull. no. 32, 1887, p. 45.
Anadia metallica Günther, Biologia Centrali-Americana; Reptilia and Batrachia, Aug. 1885, p. 30; Boulenger, Catalogue of the Lizards in the British Museum, 2nd ed., vol. 2, p. 400; Loveridge, Proc. Biol. Soc. Washington, vol. 42, Mar. 25, 1929, pp. 99-102 (*part.*).

Diagnosis: A slender lizard with a tail nearly twice length of head and body; snout-to-vent length, 58 mm.; head narrowed, pointed; limbs with five digits, all clawed; 23 scales in a transverse row around body, subequal in size; frontonasal single, separating nasals; 55 scales from parietals to level of posterior face of femur; two large preanal scales preceded by a somewhat smaller pair; occipitals enlarged. Teeth compressed with a central cusp flanked by a denticle on each side.

Description of species: (Data from Cope's type description). A slender lizard with a very long tail and feeble limbs; head narrowed and acute in front, with a produced rostral shield; frontonasal as wide as long; frontal elongate, two prefrontals, two frontoparietals, two parietals separated by an interparietal; four supraoculars; interparietal elongate having sutures parallel to the larger parietals; latter bounded externally by a large temporal, forming with them a diagonal suture; these all are bounded posteriorly by a series of four shields across the occiput, and these in turn by a transverse series of seven scales larger than those on the nape following them; nasal followed by a large loreal and this by a smaller preocular; seven supralabials, 4,3,1,2,6,7,5, being their diminishing order of size; two pairs of chinshields in contact in median gular region, the posterior pair being twice as long as the first. Nostril in a single nasal plate, tympanum distinct.

Dorsal scales all smooth in uninterrupted transverse annuli round the body, the size subequal on the various regions including the nuchal and gular; twenty scales in a cross-row between the angles of the lower jaw; scales in pectoral region irregular, the last row of the neck having the appearance of a collar; a series of 23 scales in an annulus of the body; twelve transverse rows between large postoccipital row and line of axillae; between this line and posterior line of thighs, 43 scales. There are two large, longitudinal, anal scales, which embrace a scale between them on the anal border; these preceded by another pair, but of reduced size.

Toes 5-5, all clawed. Tail nearly twice head-body length; hind limb one fourth head-body length. Limbs surrounded by large scales except on concealed faces of humerus and femur, where

the scales are small and flat; lower eyelid dried so its characters are obscured.

Color: Light gray with red and green metallic reflections; sides brown, the middle of back darker than a line above the brown of the side; near the light dorsolateral lines, a few scales are blackish, forming a row on each side; venter dusted with brown; head with deep brown sides and a white upper lip; sides of tail brown with a zigzag upper margin.

Measurements in mm.: Total length, 165; head-body length, 58; tip of snout to axilla, 17; length of head to tympanum, 11; length of head to orbit, 4.5; length of arm, 13; length of leg, 14.5.

Remarks: Cope's figure 5, plate 24, is perhaps a bit diagrammatic. There is no suggestion of the lateral series of separated light spots. Figures 2a and 2b, plate 28 are presented on a small scale but the conformation of the chinshields do not conform to the description since the second pair is shown to be very small. A third pair which is not mentioned are large, and separated from each other.

Dr. Doris Cochran has kindly re-examined the type. She writes: —"The type of *Chalcidolepis metallicus*, USNM 30568, is not in the best shape, being pretty dry, and having lost its left leg. Its right leg shows 3 femoral pores, the 3rd quite faint. Perhaps there are only 21 or 22 scales around the body,—it is too brittle to say exactly. The nasal and first labial are broadly in contact. The first pair of chinshields are as long as the mental; the second pair is a little longer than the first; the third pair is shorter than either pair 1 or pair 2, and are separated by a small scale, while the first two are entirely in contact."

It would appear that the specimen was dried when received by Cope (since he at least mentions the fact that the eyelid is dried) and the femoral pores were overlooked or an incorrect statement set down concerning them. He states—"no femoral pores."

*Anadia metallica attenuata** subsp. nov.

(Fig. 12)

Type: KUMNH No. 34223 ♂ from Pacuare, Río Pacuare, on road between Turrialba and Moravia de Chirripó, Cartago Province, Costa Rica; Aug. 17, 1951, Edward H. Taylor, collector.

Paratype: KUMNH No. 34224, Moravia de Chirripó.

Diagnosis: Frontonasals separated from the first labial or not;

* Latin, *attenuatus* = drawn out.

FIG. 12. *Anadia metallica attenuata* subsp. nov. Type and paratype. Left figure KUMNH No. 34224, paratype, Moravia de Chirripo; figure on right, type, KUMNH No. 34223, Pacuare, Río Pacuare, on road between Turrialba and Moravia de Chirripó; actual length, 177.5 mm.

rows of black dots on dorsal surface reduced or absent; dorsolateral light line extending to tail, then breaking up into two series of small clay-white spots; a series of small white or cream dots on sides from axilla to groin, those near axilla with dark borders; 9-10 femoral pores; 28-31 scale rows around middle of body; 14 rows of gular scales between chinshields and nuchal collar; scales from parietals to back level of thigh, 53-56.

Description of type: Body slender, the basal region of the tail plump and nearly as wide as body for some distance; rostral large, the part visible above about half length of frontonasal; latter longer than wide, separated from the first labial by the nasal; prefrontals rather large, each nearly half the area of the frontonasal, touching nasal, loreal, and first supraocular laterally; frontal widened anteriorly, narrowed posteriorly, about as long as frontonasal; four supraoculars, first small, three touching frontal; a pair of small frontoparietals, each touching frontal, two supraoculars, a parietal and an interparietal; interparietal shaped somewhat like frontal, the widened part posterior, the sides definitely not parallel; parietals large, their posterior part forming less than a right angle, each touching last supraocular, upper postocular, and three other large scales; the parietal series bordered behind by a row of specialized postparietals; some of the scales of the temporal area enlarged, one bordering the auricular opening; nasal single, nostril above middle of first labial; a large loreal, nearly as high as long; five supraciliary scales; four postoculars; supralabials 7-7, the fourth largest, the fifth smallest; ear-opening less than half length of eye-opening; 6-6 infralabials, the last small; mental about size of rostral; a large azygos postmental; three pairs of chinshields, the last pair largest, forming a short median suture anteriorly, separated posteriorly by two scales; first transverse gular row consisting of eight scales, the outer very large, separated from sixth infralabial by one narrow scale; 15 rows of gular scales including "collar" series; lateral scales narrower than dorsals or ventrals; small scales present about limb insertions; all scales smooth, the dorsals quadrangular, somewhat imbricating; very large scales on limbs save on underside of upper arm, and ventral and posterior part of thigh; soles, palms and basal joints of digits with padlike lamellae, only one or sometimes two divided on each toe; on two terminal joints of each digit, lamellae compressed; a strong terminal claw.

Scales in a row about middle of body, 31; dorsal scales from parietals to back level of thigh, 52; scales from posterior chin-

shields to front level of thigh, 50; subcaudals (tip of tail regenerated), 95; six preanal scales, the four median longest, second row with four scales.

Color in life: Dorsum somewhat mottled olive; head lighter with a very indefinite pattern; a pair of dirty-white or clay dorsolateral lines extending from anterior supraoculars to tail where they tend to break up on each side into two more or less regular series of cream-colored spots, but becoming more irregular towards tip of tail; a pair of short light lines in nuchal region; a brown stripe with darker edges begins behind eye, continues on neck and side of body to tail, growing lighter and more indefinite posteriorly; a few ocelli in axillary region continuing as a series of indefinite light dots to groin; limbs variegated cream-white and light brown; chin, throat, breast, and underside of arms almost pure white; venter dirty white with a very fine sprinkling of gray pigment, usually concentrated into indefinite areas on each scale; underside of tail with a light salmon wash and with some fine, scattered, brownish pigment.

Measurements in mm: Snout to vent, 58.5; snout to arm insertion, 18.7; axilla to groin, 33.5; tail, 119 (tip regenerated); total length, 177.5; arm, 12; leg, 15.5.

Remarks: The type locality is only a few kilometers from Moravia de Chirripó, where another specimen was obtained. The type specimen was captured in a field recently cleared of forest trees. The rather heavy claws suggest that the species is arboreal rather than terrestrial.

Variation: A second specimen referred to this subspecies is KUMNH No. 34224 from Moravia de Chirripó; and while not agreeing in all details it does agree in essential characters. The specimen is a female taken from a bromelia in a forest tree at some distance from the ground.

Direct comparison with the specimen just described shows but little difference in head squamation. The large frontoparietal separates the nasal from the rostral, and the interparietal has parallel sides. The supralabials are 7-6, the fourth and fifth being fused on the right side; however, there are 6-6 infralabials due to a segmenting of the large first infralabials. The scale counts from occiput to posterior level of thigh is 54; there are 16 gular and 36 transverse ventral scale-rows and 28 scales in a row around body.

The color differences are due largely to a row of small dark dots rarely covering a single scale completely. There is a small part

segmented from the third supraocular on the right side, two segments on the left side. The preanal series consists of five elongate scales preceded by a series of four smaller scales. The female has 2-1 minute femoral pores, and these are smaller than those in the male. There are two oviductal eggs present.

A specimen collected by Mr. C. H. Lancaster at Cachí, Cartago Province, "arbórea sobre el terrá, Nov. 1910. (3,300 ft.?) on the south bank of the Rió Reventazon," has been forwarded to me by Mr. Arthur Loveridge. This specimen is the one mentioned by Mr. Loveridge (Proc. Biol. Soc. Wash., vol. 42, 1929, pp. 99-102).

The specimen is somewhat faded and the dorsolateral light lines are discernible when submerged in alcohol, and the inner edges are darker than the outer. No black dorsal spots can be discerned. The olive brown lateral stripe from snout passes through the eye and along the side of the head and is lost on the side. The venter is pigmented somewhat, the chin, lips, and throat cream. The tail has been broken 26 millimeters behind the vent and the broken portion of the tail is almost uniformly cream white with little or no evidence of pigment. The basal portion of the tail shows considerable pigmentation. There are 28 scale-rows around the middle of body, and 52 scales in a longitudinal row from parietals to back level of thigh; femoral pores, 8-9; caudal whorls, 113; third pair of chinshields separated; six preanal scales, preceded by two scales; snout-vent length 57 mm., tail 144 mm. On one side the nasal touches the rostral; on the other it fails to touch, while the first labial touches the frontonasal. There is no scale segmented from the third supraocular.

Another Costa Rican specimen from "Santa Teresa" Costa Rica (a locality I do not find on my available maps) collected by Dr. Dodge "in jungle" was also loaned by Mr. Loveridge. This specimen is presumably a recent hatchling and presumably is a female. The minute femoral pores are 3-4; the caudal whorls are 109; the scales in a dorsal row 56; and there are 28 scales in a row surrounding the middle of the body. The adpressed limbs touch in this specimen while in all others here reported the adpressed limbs are separated by from 10 to 14 annuli. I am uncertain whether this is purely a juvenile character or not, but presume that it is.

The color pattern is strongly defined. The area between the dorsolateral lines shows a vermiculating reticulation of brown while anteriorly on the head the color is dark olive, more or less uniform;

dorsolateral light lines are well defined; a lateral brown stripe begins at the nasal, passes through eye, includes the upper half of the auricular opening and continues to the groin; a row of about 13 unequally spaced cream spots surrounded by black color begin above arm insertion and continue to above leg insertion, the posterior ones less distinct and lacking dark borders.

In this specimen the frontonasal makes a considerable suture with the labial anterior to the nasal and the interparietal is proportionally more elongate than on the other specimen. A small scale is segmented from the outer part of the third supralabial (as is true of KUMNH Nos. 34223, 34224, and 34225, but this is not true of MCZ No. 15386 from Cachí. Until the adult characters of a male specimen is known the placing of this female form will remain in doubt.

This specimen measures 70 mm. in total length; snout to vent, 26 mm.; the greatest width of head, 4 mm.; arm, 6 mm.; leg, 8.2 mm.

Anadia metallica arborea * subsp. nov.

(Fig. 13)

Type:—KUMNH No. 34225, from Las Flores, Tenorio, Las Cañas, Guanacaste Province, Costa Rica, Aug. 22, 1952; John Baker and Edward H. Taylor collectors.

Diagnosis: A slender, elongate species, the male with 5-5 femoral pores; 63 transverse dorsal scale series between parietal and back level of thigh; back heavily spotted with black, the spots covering from two to four scales; 28 scales in a row about middle of body.

Description of type: Body elongate, slender, the tail twice head-body length; head slender, the snout narrowed, rounded at tip; rostral large, in contact posteriorly with two labials and the frontonasal, the suture with the latter curving, the length of part visible from above about half length of frontonasal; latter single, seven-sided, forming a considerable suture with first labial anterior to the nasal; prefrontals rather large, nearly half the area of frontonasal, laterally touching the nasal, loreal, and the diminutive first supraocular; frontal relatively small, larger than the prefrontals, smaller but equally as long as the frontonasal; frontoparietals small touching frontal, two supraoculars, interparietal, and parietals; latter scales very large, terminating posteriorly in an acute angle, separated by a parallel-sided interparietal; the parietals touch last supraocular, upper postocular, and two temporals, the upper of which is

* Latin, *arboreus* = of the trees.

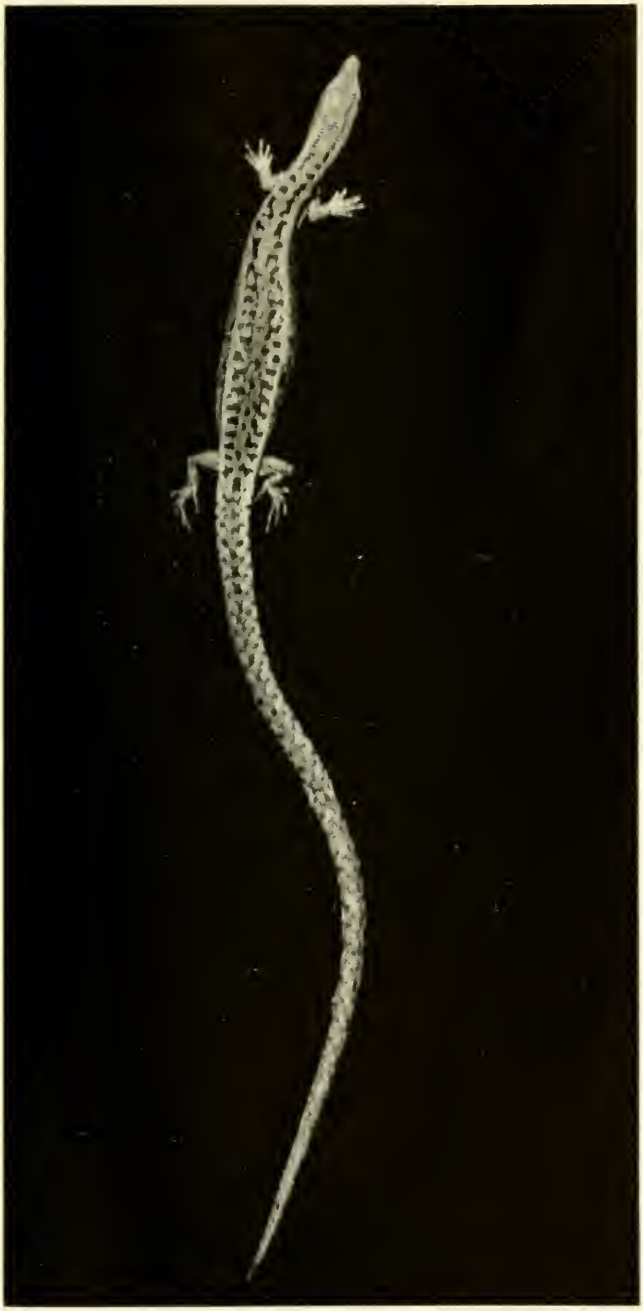

FIG. 13. *Anadia metallica arborea* subsp. nov. KUMNH No. 34225, Type. Las Flores, Tenorio, Las Cañas, Guanacaste, Costa Rica; actual length, 181 mm.

much enlarged; interparietal touches three enlarged postparietal scales; transverse series of scales following the postparietals likewise modified, larger than the nuchal series which follow behind.

Nostril in a single nasal, separated from rostral by a distance more than a third of its length, its size less than that of loreal which borders it behind; a small preocular; nostril above latter half of the first labial; four supraoculars, first very small, the series bordered laterally by five supraciliaries, a smaller second loreal (frenocular) and three small suboculars; four larger postoculars; about four series of temporals, showing much variation in size; an enlarged scale borders the auricular opening; lower eyelid well developed, with a longitudinal series of transparent scales; ear-opening nearly circular, much smaller than eye-opening.

Seven supralabials, 1,4,3,6,2,7,5 being the diminishing order of size; five infralabials, the last nearly concealed under the supralabial but bearing a brown spot; the following scale is small but likewise might be counted as the sixth infralabial, lying as it does below or under the seventh supralabial; labial border of mental equal that of the rostral; azygos postmental large; three pairs of chinshields, the first two broadly in contact, the third pair narrowly separated, narrowed almost to a point on their inner border; the second pair longer than first; three small scales lie between the posterior parts of the third pair; these followed by the first gular row consisting of nine scales, the two outer greatly enlarged and touching fourth infralabial, separated by one scale from the fifth; seventeen and two incomplete rows of gulars between third chinshields and (including) scales forming the nuchal collar; three enlarged modified pectoral scales following the nuchal collar; 37 transverse scale rows from nuchal collar to the last transverse row on abdomen; these scales square or rectangular save on breast and in last row; the preanal series consists of a small, triangular, median scale bordered laterally by two large scales that make a common suture anterior to median scale, then are separated anteriorly by another scale; these bordered laterally by a narrow elongate lateral scale and these in turn by a very small narrow scale; anterior to these is a second series of four scales.

Femoral pores 5-5, the innermost situated so that it might be regarded a preanal pore, but it is practically continuous with the femoral series; following vent there are two or three, irregular, granular series of scales; first two annuli of caudals small, the total caudal series being 108; from interparietal to back level of thigh, 62 transverse rows; the scales on side of neck, about ear and postaxil-

lary region, and about leg insertion, smaller and somewhat irregular; scales in a row about middle of body, 28. There is a tendency for the smaller axillary scales to be continued posteriorly on side for some distance. Occasionally the scale annuli are broken on back and scales tend to alternate.

Limbs slender, pentadactyl, all clawed; lamellae under palms and soles, as well as on basal portion of digits, flattened, padlike; two terminal joints of digits compressed, the lamella forming a median ridge or angle; digits more or less angular, all with strong claws; arm with large scales except on underside of upper arm; leg with large scales save on posterior part of thigh and on part of ventral surface of thigh.

Color in life: Generally light brownish olive above, the head mottled with olive; a clay-colored dorsolateral line beginning on the head passes over eyes, along neck and side of body; dorsum brownish olive above with two irregular series of black spots from occiput to tail, even continued some distance on tail but growing more indefinite on latter half; some scattered dots between the rows; a dark-edged brown stripe beginning on snout passes along side of head, becoming less distinct on side of body and tail; on this are a few small white flecks with darker borders, especially in axillary region, and an indefinite row of dark spots; a cream-white line from tip of snout covers the labials and extends back, becoming continuous with the white or cream color of the chin and venter; on belly the scales have a faint scattering of brownish pigment; chin and throat pure white. Some black spots continued on to tail; on the tail the clay-colored dorsolateral stripe interdigitates with the lateral brown stripe on basal part of tail but it gradually merges in the more uniform brownish color; a row of somewhat quadrangular light spots along ventrolateral part of tail; limbs tan with numerous, more or less distinct, small brownish spots.

Measurements in mm. and scale data of KUMNH No. 34225: Sex, ♂, snout to vent, 63; snout to arm insertion, 20; axilla to groin, 39; tail, 118; total length, 181; arm, 12; leg, 15; femoral pores, 5-5; scales around body, 28; scales from parietals to back level of thigh, 63; scale-rows from chinshields to front subcaudals, 108; scales from nuchal collar to front level of thigh, 37.

Remarks: This specimen was discovered on a tree bole some eight feet from the ground by John Baker. Despite its short, rather weak limbs it ran with dexterity but I finally managed to capture the specimen by driving it down with a long pole until it was within reach.

Leposoma southi orientalis * subsp. nov.

Leposoma southi Ruthven and Gaige (*part.*), Papers Mus. Zool., Univ. Michigan, no. 147, 1924, p. 1-3 (specimen from Museum of Comparative Zoology, Harvard College, from Suretka on the Sixaola River, Costa Rica, that "corresponds fairly well with *L. southi* with the exception of the chin shields").
Leposoma dispar Burt and Burt (*part.*), Bull. Amer. Mus. Nat. Hist., vol. 61, art. 7, 1931, pp. 347-349 (two specimens, MCZ Nos. 18916-17).
Leposoma southi Ruibal (*part.*), Bull. Mus. Comp. Zool. Harvard Col., vol. 106, no. 11, June 1952, pp. 484-485 (at least Suretka specimens, MCZ Nos. 18916-17).

Type: KUMNH No. 36124 ♂, from Volio, Limón Province, Costa Rica; Edward H. Taylor, collector, June 24, 1954.

Paratype: No. 36125 ♀, taken with the type, same place and date.

Diagnosis: A small species, maximum known snout-to-vent length, 36.5 mm.; preanal pores, 2-2; femoral pores, 4-4. Differs from *Leposoma southi southi* in having gular scales larger and in fewer (two to four) rows; two pairs of chinshields, both in contact; third chinshield replaced in this form by two scales of equal or unequal size and the two followed by three somewhat enlarged scales; body more slender with five, rather than seven, dorsal scale rows. Scales around body, 19 to 21; transverse rows on venter from breast to preanal scales, 18-20; transverse dorsal scale rows from occiput to back level of thighs 29-30; eye smaller and ear longer; eye disc divided into four or five scales rather than two; dorsolateral stripe very indistinct if present.

Color: The head is a dark brownish-black save that each of the labials has a dark spot except the sixth which is uniformly dark. The dorsal surface is brownish tan with some scattered pigment except on the anterior part of a dorsolateral scale-row which may lack pigment entirely. The sides are more heavily pigmented forming a dark stripe from neck to tail. On the ventral surface the chin is cream white, the venter and base of the tail being somewhat pinkish.

Measurements and scale data on type and paratype: Nos. 36124 ♂, 36125 ♀: snout to vent, 36, 36.5; snout to arm insertion, 13.8, 13; tail, 41,† 61; total length, 77, 97.5; arm, 11.8, 9.5; leg 13, 13.2; axilla to groin, 18, 18.2; supralabials, 6-6, 6-6; infralabials 5-5, 5-5; scales around body, 19, 20; occiput to back level of thigh, 31, 30; subcaudals,—, 66; scales on eye disc 4-4, 3-4; femoral pores 4-4, 0-0; preanal pores, 2-2, 1-1.

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* Latin, *orientalis* = of the East.
† Regenerated.

Genus Lepidophyma A. Duméril

Lepidophyma A. Duméril, in Duméril and Duméril, Catalogue méthodique de la collection des reptiles (Paris Museum), 1851, pp. 137-138 (type of genus, *Lepidophyma flavimaculatus* A. Duméril); Cope, Proc. Acad. Nat. Sci. Philadelphia, 1883, p. 30.

Poriodogaster A. Smith, *in* Gray, Proc. Zool. Soc. London, 1863, p. 154 (type of genus *Poriodogaster grayii* Smith).

Akleistops Müller, Verh. naturf. Ges. Basel, vol. 6, 1878, p. 390 (type of genus, *Akleistops guatemalensis* Müller).

Description of genus: Body and tail rather rounded; head widened posteriorly; eye without distinct eyelids; no teeth on palate; scales of head thin, smooth except for minute tubercular rugosities; nostril surrounded by three scales. Frontal very large, divided mesially; no supraoculars present; a row of small superciliaries; lower labials and chinshields completely fused, the labials having the general appearance of chinshields; anterior nasals forming a median suture; frontonasal, frontoparietals, interparietal (bearing an eyespot), and parietals present; three enlarged temporals. Body covered on sides and back with granules intermixed with transverse (vertical) rows of larger conical or trihedral tubercles; a pair of longitudinal tubercular rows dorsally; tail segments covered with transverse rows of complete or partial annuli; venter with quadrangular scales in transverse and longitudinal rows; throat covered with equal granules; a nuchal fold; usually a longitudinal fold on side of neck from behind ear, and a pair of folds on neck.

The genus has entered Costa Rica from the north along both coasts and has extended itself at least to the Canal Zone in Panamá. The literature references of the genus in lower Central America are few. In some cases the southern specimens have been referred to *Lepidophyma flavimaculatum* A. Duméril. The following have been reported: one from Honduras (Werner 1896); one from Nicaragua (Río Mico, Caribbean drainage, Gaige, Hartweg and Stuart 1937); none reported from Costa Rica; one from Panamá (referred to *Poriodogaster grayii* Peters 1874); one from Río Chilibrillo, Panamá and one from Barro Colorado I., Canal Zone (Barbour 1924, described as *L. f. obscurum*).

On the whole, the genus is a conservative one and for the most part general body form and general characteristics remain the same throughout. However, certain characters are affected by evolution, producing differences worthy of nomenclatorial recognition. At the same time other, perhaps major characters may be variable within specialized populations.

One of the difficulties in studying the genus in Central America

is that only in a few cases are adequate museum series available from any locality.

The specimens from Costa Rica in my collection number 58, of which 19 are from six localities in the Caribbean drainage; while 39 are from five localities in the Pacific drainage area.

The Costa Rican specimens are regarded as belonging to three forms, two presumably confined to the western, Pacific drainage, and one to the eastern, Caribbean drainage. They are lowland forms, none having been found above an elevation of 3,000 feet. It is doubtful that any of the forms are completely isolated geographically. Two of them occur together at Tilarán, Guanacaste.

Whether these forms are species may be questioned. I here regard them as species, aware that future study may bring evidence to the contrary.

Mertens (1952) has recently reported *Lepidophyma smithi smithi* Bocourt from El Salvador. While he does not describe the conformation of the squamation in detail he does give the following significant information:

1. A median prefrontal present (one case a double scale).
2. Three scales between the whorls of larger caudal scales (four to a segment).
3. Femoral pores (1 specimen) 5-7.
4. Four dark longitudinal bands on brown ground color on which are rows of yellow flecks.
5. Chin region of all with darker markings.

Mertens had four examples, the largest having a snout-vent length of 66 millimeters, the tail 101 mm.; two smaller specimens were 39-42 mm.; and 59-61 mm. respectively.

It will be apparent that the species found in El Salvador differs markedly from the two found in the Pacific drainage of Costa Rica.

KEY TO THE COSTA RICAN SPECIES OF LEPIDOPHYMA

1. Throat region behind chinshields strongly marked with dark brown or black reticulations enclosing rounded cream spots. Second pair of chinshields separated by small scales; postocular scales wider. First loreal higher than second nasal; no trace of lateral stripe; 14-17 femoral pores; Pacific drainage,

   Lepidophyma reticulatum sp. nov.

   Throat region behind chinshields lacking definite reticulations, the area usually light with nearly equal distribution of pigment, or a few light brown dots; second pair of labials forming a median suture; anterior loreal lower or higher than posterior nasal; postocular scales narrower 2

2. Femoral pores 13-15; a pair of postparietals or partial sutures marking the same; first loreal higher than the posterior nasal. Caribbean drainage ..... *Lepidophyma anomalum* sp. nov.
Femoral pores 16-18; no trace of postparietals or partial sutures marking same. Five transverse complete or partial caudal annuli dorsally on each segment of tail; posterior nasal higher than first loreal, which is separated from frontonasal. Pacific drainage, *Lepidophyma ophiophthalmum* sp. nov.

The literature on the genus, especially as it applies to Central America, is scattered. I include the following series of bibliographic references for the recognized forms, *flavimaculatum flavimaculatum, f. obscurum, smithii smithii,* and the doubtful *grayii.* I cannot vouch for the correctness of the synonymy since it is possible that some of the reports have been confused.

Lepidophyma flavimaculatum A. Duméril

Lepidophyma flavimaculatus A. Duméril, in Duméril and Duméril Catalogue methodique de la collection des reptiles (Paris Museum), 1851, pp. 138-139 (type locality: restricted locality, Río de la Pasión); A. Duméril, Rev. Mag. Zool., 1852, p. 409, pl. 17; Sumichrast, Arch. Sci. Phys. Math., Mar. 1873, p. 251.

Lepidophyma spec. Müller, Verh. naturf. Ges. Basel, vol. 6, 1878, p. 627 (Verapaz, Guatemala).

Lepidophyma flavomaculatum Bocourt, Mission Scientifique au Mexique et dans l'Amérique Centrale; Études sur les Reptiles, livr. 5, 1878, pp. 306-309, pl. 20 F, figs. 2, a-g (also spelled *flavimaculatum* on page facing plate); Boulenger (*part.*), Catalogue of the lizards in the British Museum (Natural History), 2nd Ed. vol. 2, 1885, pp. 326-327 (Tehuantepec, Mex.); Werner, Verh. zool-bot. Ges. Wien, Jahr 1896, p. 4 (Honduras) p. 9 (Guatemala); Abh. Wiss., Band 22, Abt. 2, p. 345; Barbour, Proc. New England Zool. Club, vol. 9, Jan. 24, 1924, p. 9 (southeastern part of Mexico, Yucatán and the Caribbean coastal plain of Guatemala, British Honduras and Nicaragua [M.C.Z.]); Stuart, Copeia 1937, no. 1, Apr. 10, p. 69 (along Río de la Pasión near Petén-Alta Verapaz border [exact locality unknown]); Misc. Publ. Mus. Zool. Univ. Michigan, No. 69, June 12, 1948, p. 55 (El Petén, 3 spec.); Cont. Lab. Vert. Biol. Univ. Michigan, no. 45, May 1950, pp. 23, 56 (below 900 m.).

Lepidophyma smithi smithi Bocourt

Lepidophyma smithii Bocourt, Journ. Zool., Paris, 1876, vol. 5, p. 403 (type locality: restricted locality, Mazatenango, Guatemala); Mission Scientifique au Mexique et dans l'Amérique Centrale, Étude sur les reptiles, livr. 6, 1878, pp. 309-312, pl. 20 F, fig. 3, a-b; pl. G. figs, 2, a-b; Müller, Verh. naturf. Ges. Basel, vol. 6, 1878, p. 627 (Mazatenango, Guatemala); Barbour, Proc. New England Zool. Club, vol. 9, Jan. 24, 1924, pp. 9-10 (Pacific coastal plain of southwestern Mexico and Guatemala).

Akleistops guatemalensis Müller, Nat. Ges. Basel, vol. 6, 1878, pp. 390-398, pl. 1; pl. 2, figs. 1-5 (type locality: "Mazatenango, coste grande de Guatemala").

Lepidophyma maculatum (*part.*) Boulenger, Catalogue of the Lizards in the British Museum, 2nd Ed., vol. 2, 1885, pp. 326-327.

Lepidophyma smithi smithi Smith, Proc. U. S. Nat. Mus., vol. 92, no. 3153, 1942, p. 380; Smith and Taylor, U. S. Nat. Mus. Bull. 199, 1950, p. 152; Mertens, Abh. Senckb. Naturf. Ges., No. 487, 1952, p. 53, pl. 11, fig. 61 (San Salvador).

Lepidophyma grayii (A. Smith)

Poriodogaster grayii A. Smith, *in* Gray, Proc. Zool. Soc. London, 1863, p. 154, pl. 21 (unknown locality); Peters, Proc. Zool. Soc. London, 1874, p. 307. (Specimen from Panamá thought to be identical with this species, suggesting Panamá as the type locality. Bocourt states that this specimen has 17 femoral pores on each side).

Lepidophyma flavimaculatum obscurum (Barbour)

Lepidophyma flavomaculatum obscurum Barbour, Proc. New England Zool. Club, vol. 9, Jan. 4, 1924, pp. 9-10 (type locality, Río Chilibrillo, Panamá; known also from Barro Colorado Island, Canal Zone).

Barbour has based his form on two specimens from Panamá (Río Chilibrillo, and Barro Colorado Island, Canal Zone). His description is extremely brief consisting only of the following: "In squamation very similar to *L. f. flavomaculatum*. It differs in having relatively a slightly smaller and narrower head; in having the longitudinal rows of enlarged dorsal scales more straight, more even, and more closely and regularly beset with longer spine-like scales. The color is blackish brown, and the yellow rosette-like spots are only about one half of the size, each, of those in the northern subspecies, of which apparently it is an offshoot, typically colored for the humid forest, as the other is for a more xerophilous life." Whether this is identical with Peters' specimen (see above) can only be determined when the two specimens are compared and these in turn compared with the type of *Poriodogaster grayii*.

I have examined one Panamanian specimen identified as *L. flavimaculatum obscurum* (USNM 65809). In this there were no lateral light spots on the back and sides of body but some at base of tail. There are five labials preceding the subocular labial that have small cream spots. The venter is uniform dark brown. The tail is broken and a single segment remains, so that the character of the caudal squamation cannot be ascertained. The femoral pores are 13-14 (female). The preanals consist of a posterior pair bordered laterally by several tiny scales. The pair preceding these is smaller and longer than wide and preceded by two small regular pairs. The medial prefrontal is large, about half the area of the outer prefrontal. There is no trace of postparietals.

This specimen measures 103 mm. snout to vent; snout to arm, 39.5 mm.; axilla to groin, 48 mm.; arm, 30 mm.; leg, 41 mm.; width of head, 17 mm.; length of head, 25 mm.

Lepidophyma reticulatum * sp. nov.

(Fig. 14)

Type: KUMNH No. 36245 ♀, Agua Buena, Puntarenas Province, Costa Rica, July 25, 1954; Edward H. Taylor collector.

Paratypes: Nos. 36238-36244, 36246-36249, topotypes, same date and collector; Nos. 34189-34193, 3 km. E San Isidro del General, San José Province; Nos. 34194-34202, 34204, 15-17 km. WSW San Isidro del General, Puntarenas Province; Nos. 36230-36237, 4-5 km. NE Tilarán, Guanacaste.

Diagnosis: Large species with approximately 38 caudal segments, each, except first, with five rows of partial or complete scale annuli crossing dorsal surface of tail (rarely six), the terminal segments not clearly marked; a median prefrontal absent (or present in some specimens in the San Isidro del General region); no trace of postparietals; femoral pores in both sexes, 14-17 (average 15.4); the first loreal higher than posterior nasal and touching frontoparietal; only first pair of chinshields in contact behind mental. Throat strongly reticulated with dark blackish-brown enclosing cream spots; scales with small glandular pores.

Description of type: Head nearly triangular seen from above; snout rather pointed, the rostral wider than high, narrowly visible above; anterior nasals broader than high, forming a median suture; frontonasal eight-sided, broader than long; two prefrontals, their outer edges bent down over canthus rostralis, smaller than the divided frontals; outer edges of frontal separated from orbit by a small row of supraciliaries; no supraoculars; interparietal slightly wider anteriorly than posteriorly, pushing in between posterior part of frontal scales, separating broad frontoparietals completely, and touching both parietals; latter longer than wide bordered laterally by two temporals the anterior of which is more than triple size of posterior; nostril surrounded by three scales: first labial, anterior and posterior nasals; first loreal higher than nasals, its length about one third the length of the second loreal which is nearly as high; two presuboculars and a very narrow linelike preocular; five supraciliaries; five postoculars; two minute suboculars separate fifth supralabial from the orbit; first upper temporal twice as wide as postoculars, lower small; between sixth and seventh labials and second upper temporal two rows of small temporal scales; seven supralabials (eighth scale very small); the seventh and eighth scales

* Latin, *reticulatus* = reticulated, netlike.

FIG. 14. Inner figure, *Lepidophyma reticulatum* sp. nov. Paratype. KUMNH No. 34194 ♀. 10 mi. SW, San Isidro del General. Outer figure, *Lepidophyma anomalum* sp. nov. KUMNH No. 34207 ♀. Type. Actual length 233 mm.

separated from mouth by granules; a row of somewhat larger tubercles border edge of ear opening, and these preceded by two or three still larger moundlike scales; infralabials (fused labials and chinshields) four, only the first pair in contact; second pair largest, narrowly separated mesially; fourth about one-fifth times as large as

third; posterior part of lower lip bordered by several granules; mental large, its labial border three times that of rostral border; on throat and sides of neck, conical granules; ear-opening large, its greatest diameter approximately 4 mm.; vertical diameter of orbit, 3 mm.; length of eye to tip of snout, 7.5 mm.; distance from orbit to ear-opening 8 mm.; a pair of ventral longitudinal folds on neck; a pair of short lateral folds running back from ear; a transverse nuchal fold.

Body covered with small conical or moundlike granules intermixed with larger conical, trihedral or irregularly shaped tubercles that tend to form vertical rows on sides of body; a pair of longitudinal rows on dorsum separated from each other by four or five rows of granules; tail segments marked by series of annular rings of scales increasing in size posteriorly; the first two definite segments with large tubercular whorls, and these separated by two small granular rows; first typical segment with five partial or complete annular scale rings, the scales growing larger towards the ventral part so that the median ventral part of each segment has only three scales; tip of tail regenerated in type. Scales on limbs varied in size, the hind leg especially with numerous larger tubercles; palm and sole with somewhat conical granules; digits with varied ventral scales, those on proximal regions conical or trihedral; in medial parts digital lamellae divided unequally, distally they are complete (or an occasional one divided).

Scales on breast flat, subimbricate, becoming elevated laterally; venter with flat juxtaposed scales arranged in eight longitudinal rows with an addition of a partial lateral row of more elevated scales on each side; about thirty transverse rows from axiliary level to the inguinal level.

Scales on under side of thigh somewhat subimbricate anteriorly; femoral pores 17-15; two pairs of larger (slightly irregular) preanal scales preceded by a very small pair.

Color in life: Head brown with some indefinite dark marks tending to form a somewhat symmetrical (somewhat radiating) pattern. Supralabials with cream marks on sutures; infralabials each with a large black spot or diagonal bar separated by cream; throat strongly reticulated with brownish black enclosing cream spots. On side of head and neck rounded cream spots surrounded by black; body black on back and sides with six longitudinal series of irregular cream spots; arms and legs with a few conspicuous spots. A pair of larger cream spots on tail above vent; segments of tail with a series of vertical cream lines chiefly on the largest tubercular scale

series; median part of dorsal surface black; ventral surface with cream predominating anteriorly and black posteriorly; femoral pores and adjoining scales cream; venter dirty cream with some dark flecks along ventrolateral region; fingers and toes ringed with cream; anal scales bluish white.

Measurements in mm.: Snout to vent, 92; tail, 120; length of head, 20; width of head, 16.2; snout to arm, 33; axilla to groin, 45; arm, 30; leg, 41.

Variation: The topotypic specimens agree closely with the type in most characters. There is no trace of the median prefrontal; the first loreal has the same relation to the posterior loreal and the posterior part of the nasal, and the femoral pores average approximately 16 on each side. Two have the preanal scales irregular. The scale rows on the dorsal part of the tail segments are five, but in two specimens six may appear on one or two segments. The total number of segments is approximately 38, however, on the posterior part of the tail the segments are not well differentiated.

The specimens that occur at San Isidro del General differed most in that a median prefrontal was present in those from near the town, while in those from a somewhat lower elevation, at a locality 15-17 kilometers west-southwest of the town, five have the prefrontal present, four have the scale partially segmented. Two of these specimens have six annular rings on several segments of the tail.

Those taken still farther north at Tilarán lack all trace of the median prefrontal. The head markings are very indefinite. One specimen has a bifid tail, where it has been regenerated. There are other smaller, less significant characters that can be used to separate these various groups of specimens. In all, the throat maintains the heavy reticulation, the postocular series is enlarged, and the anterior temporal is proportionally small.

Lepidophyma anomalum * sp. nov.

(Fig. 14)

Type: KUMNH No. 34207 ♀, Los Diamantes, Guápiles, Limón Province, Costa Rica; Sept. 3, 1947; Edward H. Taylor and Richard C. Taylor, collectors.

Paratypes: KUMNH Nos. 34205-34206, 34213, topotypes, same date and collectors; No. 34210, Bataan, Limón Province; Nos. 34211-34212, 34214-34216 La Lola, Limón Province, Nos. 36256-36257, Puerto Viejo, Limón Province; No. 34208, Morehouse Finca, Turri-

* Greek, *anomalos* = abnormal.

alba, Cartago Province; Nos. 36251-36255, Suretka, Limón Province; No. 34209, Costa Rica (uncertain provenance).

Diagnosis: A large species, with approximately 35 caudal segments, the basal seven to twelve with four complete or partial scale annuli, dorsally; the following segments with five annuli; terminal three or four segments not clearly differentiated; a median prefrontal normally present; first two pairs of infralabials in contact behind mental; femoral pores in males and females 13-15 (average about 14); throat cream with a few tiny, scattered, brown dots the size of the scales between neck folds, but no reticulation of black or brown and no cream spots; usually a pair of postparietals completely or partially segmented from parietals; body and caudal scales each with a small glandular pore. Two dorsal rows of spots, light tan; lateral spots cream.

Description of type: Head, seen from above, subtriangular, pointed anteriorly, the border of the head plates tending to be slightly angular posteriorly on the occiput, and with a slight median longitudinal depression in the parietal region; rostral wider than high, angular medially; anterior nasals form a median suture about two thirds the greatest width of the scale; frontonasal eight-sided, and distinctly wider than long, touching first loreal; three prefrontals, the median little more than one-third times the area of the outer scales; frontal divided mesially, separated from orbit by superciliaries, angular posteriorly; interparietal bearing an eye-spot, subhexagonal, only slightly wider anteriorly, somewhat narrowed near the middle, separating completely the frontoparietals; latter scales with their long axis diagonal, touching one supraciliary, one postocular and two temporals; parietals distinctly longer than wide; postparietals only partially indicated by a pair of grooves directed diagonally backward from the sutures with the interparietal; second nasal much higher than first, much higher than long (wide), not as high as second loreal, not separating it from frontonasal; first loreal as high as second but only half its length (width); a slender linelike preocular four times as high as wide; one presubocular; four narrow postoculars and five small supraciliaries; first temporal much wider (four times) than adjoining postoculars; second temporal large, about five times area of first temporal, about four times area of second; eight supralabials, first high forming with the nasals the border of nostril, fifth below eye and separated from the orbit by a linelike scale, sixth largest, touching two or three postoculars, but separated from the first and second temporals by

one or two rows of granular temporals, last labial very small; three anterior infralabials (fused labials and chinshields) large, both forming median sutures, the second pair partially separated on the median line; last two small with two differentiated scales bordering them; mental large, angular posteriorly; a small anomalous triangular scale (true infralabial?) lying between the mental and first large infralabial on each side; auricular opening large, with a row of about seven larger tubercles along its outer border, its height four millimeters; orbit of eye circular; no evidence of eyelids; orbital diameter three fourths the height of ear-opening; distance between orbit and tip of snout (7 mm.) less than distance between orbit and ear; a pair of longitudinal folds along outer ventral surface of neck; lateral fold from ear to shoulder, and a transverse nuchal fold; body and sides covered with small, conical or moundlike granules, intermixed with larger, conical, trihedral, or pyramidal tubercles, the latter forming vertical, transverse rows laterally; a pair of longitudinal rows of tubercles on back, separated by five rows of subequal granules; chin (partly) and throat covered with subequal granules; breast and venter covered with flat, juxtaposed, quadrangular scales, forming ten longitudinal rows, and between axilla to groin levels, about 27 transverse rows; scales on breast smaller, somewhat irregular; tail with each segment bearing posteriorly a whorl of larger tubercles; on first basal segment the large whorls are separated by two, on second by four smaller whorls, while the following six segments have them separated by three complete or partial whorls; from here on they are separated by four whorls. Thus each segment has either four or five complete or partial whorls dorsally; but ventrally, where the scales are larger, there are two or three only.

Arms and legs covered with granular scales, with some intermixed tubercular scales, especially on upper parts of hind leg; those on arm semispinose; some much enlarged scales on outer ventral surface of tibia; subdigital scales may be granular near base, the lamellae tending to be unequally divided except on the distal half. Female with fifteen pore-scales, most of which are pierced, and the three or four proximal and four or five distal ones show larger, perhaps functional pores. First preanal scales large, longer than wide, with a small scale on each side, and preceded by a second pair; these in turn preceded by a row of four scales.

Color in life: Dorsal part of head brown, with evidence of some darker marking, the area above eye distinctly darker; body black

dorsally and laterally, with six rows of spots, those on the dorsal surface somewhat indistinct, tan in color; lateral rows of spots brownish cream; tail blackish brown with very narrow vertical cream lines marking tubercular whorls on sides of tail; a vertical cream line in front of eye; cream dots on supralabials between black spots; infralabials with black spots or bars separated by brownish cream (fawn); chin dirty white, with a few fine brown flecks; cream spots present on cheeks and on sides of neck; the periphery of the ventral scales with much brownish pigment leaving the central part of scales lighter; preanal scales bluish white; subcaudal scales brown, mixed with cream; femoral pore-scales cream; arm and leg blackish brown with some cream spots.

Variation: The femoral pores are smaller in this species and the number is somewhat reduced varying between 12-15 (one specimen has 16 on one side). Four of the specimens (the type, and Nos. 34208, 34215, 34216) have small intercalary "labials" following the mental on the border of mouth. In the last three specimens and No. 36257 there is a small scale segmented from the outer anterior part of the parietals on one or both sides; only two specimens have the median interparietal completely missing; two specimens have five labials anterior to the subocular but this is a case of the second or the fourth labial being segmented. Two specimens have the large temporal segmented into two unequal scales, the segmented section being the outermost part. The most striking variable character is the development of a pair of scales (postparietals) segmented from the inner parts of the parietals behind the interparietal. Eight of the specimens (6 of them from Bataan and La Lola) have the pair complete or practically so; six others show partial suturing of

Table of Measurements of *Lepidophyma anomalum* sp. nov.

Number	Snout-vent	Tail	Axilla to groin	Arm	Leg
36257	104	132*	31	42	49
34207	96	137	29	40	47
36254	84	117	29	39.5	39
34211	81	*	27	38	36
36255	71	*	22	30	31
36253	67	*	22	30	30
34208	62	86	21	26	28
34205	44	62	16	19	19.5
34206	42.5	*	14.5	18	18.2
36256	42	*	15	21	23
36252	41	53	13.2	18	18
36251	41	53	13	18	18
34213	38	50	12.2	17	16.2
34215	38	47	12	17	16
34212	35	*	12	16	16

* Tail regenerated or partly missing.

the scales while five from Suretka, Los Diamantes, and Puerto Viejo have no trace of this character. It was noted that in three tiny specimens from La Lola the loreal was not higher than the posterior nasal and in one case the posterior nasal excluded the first loreal from the frontonasal. Two specimens showed some variation in the character of the anal scales by having a partial row of small scales separating first and second pairs. In the younger specimens the basal subcaudals seem to be slightly keeled. In one, there were two presuboculars. The pores in the body and caudal scales are small; those on the venter can be distinguished only with difficulty.

*Lepidophyma ophiophthalmum** sp. nov.

(Fig. 15)

Type: KUMNH No. 36250; 5 km. NNE Tilarán, Guanacaste, Costa Rica, Aug. 16, 1954; Edward H. Taylor, coll.

Paratypes: KUMNH Nos. 34217-34219, Las Flores, Tenorio, Las Cañas, Guanacaste (near base of Volcán Tenorio), Aug. 22, Edward H. Taylor and John Baker, colls.

Diagnosis: Superficially closely resembling *Lepidophyma reticulatum* in color and marking. Median prefrontal present or absent; chin lacking reticulation, light colored save for brown dots the size of granules; posterior nasal much higher than anterior, and higher than first or second loreal; first loreal separated from frontonasal; second pair of labials forming a common suture; vertical diameter of ear-opening a half greater than diameter of orbit; frontonasal hexagonal; 35 caudal segments all with five complete or partial annular scale rings except terminal three or four where segments are ill defined and may be reduced to four annuli; parietals proportionally longer and narrower than in *reticulatum;* frontoparietal narrowed laterally where it touches the last supraciliary and upper postocular; first pair of preanal scales bordered laterally by a small preanal; a partial or complete row of small scales between first (larger) and second preanal pair; femoral pores 16-18; anterior temporal distinctly larger than in *L. reticulatum.*

Description of type: Head outline generally triangular seen from above; snout pointed; rostral wider than high, rising to a sharp angle mesially, distinctly visible seen from above; anterior nasals wider than high, their inner median height at suture little more than half of outer height at nostril; frontonasal hexagonal, slightly broader than long; two large prefrontals, their outer edges bent down over

* Serpent eye. Greek. From *ophi* snake and *ophthalm* eye.

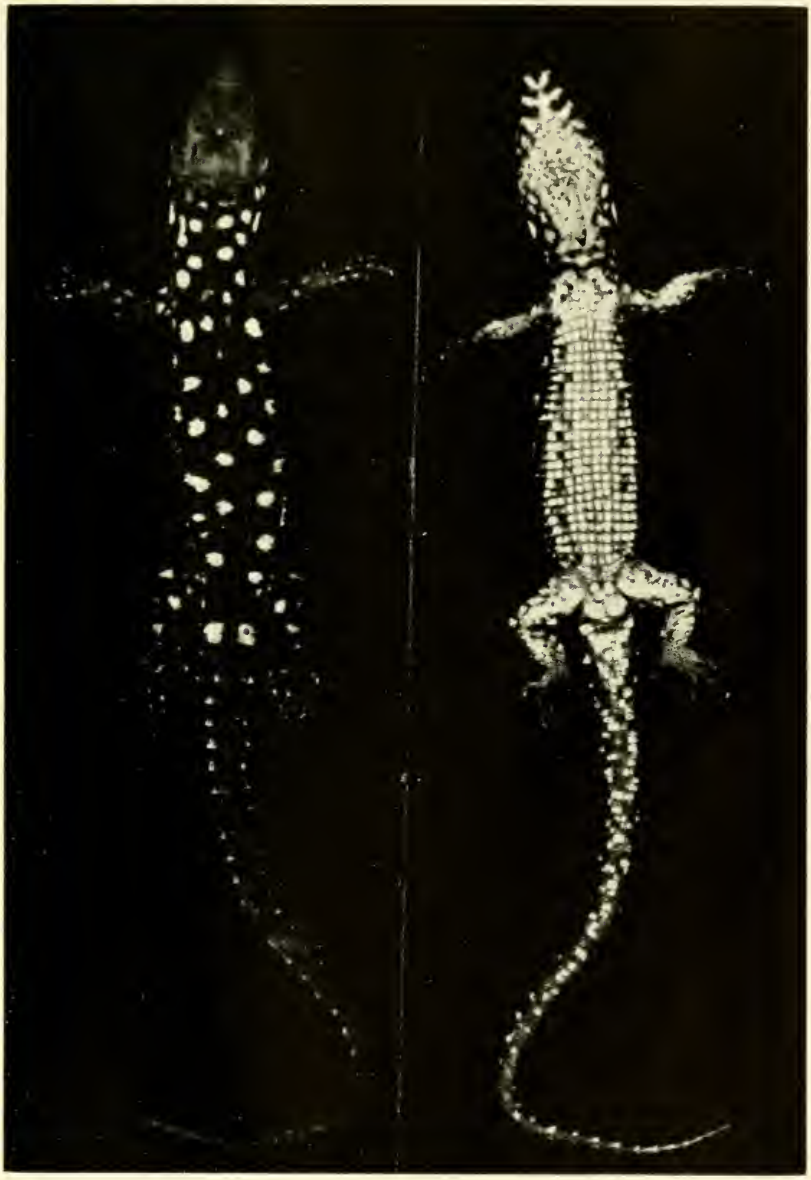

Fig. 15. *Lepidophyma ophiophthalmum* sp. nov. Type. KUMNH No. 36250, five km. NNE Tilarán, Las Cañas, Guanacaste Province, Costa Rica. Total length, 183 mm.

canthal edge, laterally touching posterior nasal, both loreals, first supraciliary and preocular; frontal large, its front borders straight, transverse, angular posteriorly, separated from orbit by a row of three or four somewhat projecting supraciliaries; frontoparietals six-sided, narrowed anteriorly; interparietal wider anteriorly, subhexagonal, separating completely the frontoparietals, with an "eye-spot" that is white with a black spot showing in its middle; parietals (6 mm. x 3½ mm.) six-sided; first temporal relatively large (2.5 mm. x 2 mm); second temporal very large, third, less than one-third times size of second; scales in preauricular region small, variable in size; auricular edge bordered by a row of seven heavier scales nearly hiding another smaller inner row; a pair of longitudinal skin folds on outer ventral surface of neck; a less distinct fold from behind ear to nuchal fold; a transverse nuchal fold. Eye circular without evident lids, the diameter of orbit (2.8 mm.) less than height of auricular opening (3.6 mm.); distance between tip of snout and orbit (6.5 mm.) less than distance between orbit and ear. Body covered with small conical or moundlike granules, interspersed with large conical or trihedral, spinelike tubercles forming vertical lateral rows; a pair of longitudinal rows on dorsum, separated from each other by four or five irregular rows of subequal small granules; the larger tubercular scales form continuous series around tail, one large series on posterior part of each tail segment. Nostril surrounded by three scales; posterior nasal higher than loreals or anterior nasal, widened at top, separating the first loreal from frontoparietal, touching prefrontal; anterior loreal twice as high as long, one third length (width) of second but nearly as high; a long, narrow preocular; one presubocular; three postoculars, lowest largest; fifth labial below orbit separated from it by two granular scales; sixth labial separated from first two enlarged temporals by a small lower anterior temporal and two granular rows of temporals; first (upper) temporal more than three times width of upper postoculars. Seven supralabials, first reaching up to nostril, sixth largest, nearly twice as long as high; last small, separated from edge of lip; four lower labials very large (fused labials and chinshields); two anterior pairs making mesial sutures, the second pair much larger than others; mental with a labial border double that of rostral, angular posteriorly; posterior part of the mouth opening bordered by granules. Tail segments approximately 36, each covered with five complete or partial rows of subconical scales, the posterior row composed of much larger tubercles; ventrally each segment with three, rarely

four scales, larger than the lateral or dorsal scales; arms and legs covered with small granules intermixed with larger ones, some of those on under surface of thigh subimbricate; femoral pores 16-16 in small single scales; subdigital lamellae variable, sometimes divided or broken up into small tubercular scales at base of third and fourth toes; distal lamellae usually complete; scales on venter flat, quadrangular, subequal except those on breast which are smaller, arranged in 10 longitudinal rows and 26 transverse rows from level of axilla to level of groin; on part of the transverse rows one counts 12 scales, but the outer row on each side is irregular, variable, the scales not flat. Most if not all scales on body and tail with pores or glands visible under magnification. Preanal scales consist of a posterior row of two much enlarged scales and two smaller lateral scales; median row broken leaving the third pair on left side touching a large posterior scale; third row has two scales, larger than those in median row.

Color in life: Head brownish with some indefinite darker marking; black spots on loreals and supralabials separated by small cream spots; infralabial and mental with dark bars, separated by white; chin dirty white with a few brown granules; sides of neck with large cream spots on black background; body black with six irregular rows of lighter spots; venter scales heavily dusted with brown leaving a whitish central area; outer rows of ventral scales with a nearly continuous, irregular white line; femoral pore-scales white. Arms and legs spotted white; tail with irregular white spots on sides, one to each segment, variable in size and position; under side of tail blackish with some white scales; preanals bluish white.

Measurements in mm.: Snout to vent, 77; tail, 106; head width, 13.8; head length, 18; snout to foreleg, 31; snout to ear, 18.5; axilla to groin 36; arm, 23.5; leg, 35.

Variation: The three paratypes are from a locality 20 kilometers northwest of the type locality, at Las Flores on the large cattle ranch of Tenorio, a place situated near the base of Volcán Tenorio but at about the same elevation as the type locality. The two smaller specimens have a median prefrontal which is lacking in the adult. The median row of preanals is complete in the young, broken in the adult. There are 16 to 18 femoral pores present in all.

Anomalepis dentatus Taylor

Anomalepis dentatus Taylor, Proc. New England Zool. Club, vol. 17, June 26, 1939, pp. 90-91, pl. 5, figs. 1-3 (type locality, Barro Colorado Island, Canal Zone); Taylor, Univ. Kansas Sci. Bull., vol. 34, pt. 1, Oct. 1, 1951, pp. 24-25.

A small snake of the genus *Anomalepis* taken at a point about four kilometers southeast of Los Angeles de Tilarán, Province of Guanacaste, proves to belong to this species. The specimen is 156 mm. in total length, of which 3.1 mm. represents the length of the tail.

The scale counts are as follows: Scales from rostral to tip of tail, 271. On the ventral surface from mental to vent, there are 264 scales; from vent to end of tail seven subcaudals. The longitudinal scale-rows about body are 28, 24, 22, 20. When scale-rows drop out they do so by a fusing of two scale-rows, thus forming some enlarged scales. The subsequent scales become gradually smaller. Two mandibular teeth are present, separated by a mesial diastema. The conformation of the head scales is very much the same as depicted by Taylor, *loc. cit.* save that the scales, lateral to the frontal, are slightly larger than they appear in the dorsal view of figure 3 since the scales are drawn in perspective. The preanal scales are in contact posteriorly.

No evidence whatever has been brought to bear that *dentatus* is a synonym of *Anomalepis mexicanus.* The differences as portrayed in the characteristics of the large head scales, especially their proportions, is strong evidence to the contrary.

Leptotyphlops ater * Taylor

Leptotyphlops ater Taylor, Univ. Kansas Sci. Bull., vol. 26, no. 15, Nov. 15, 1940, pp. 536-538, fig. 4 (type locality, Managua, Nicaragua).

A Costa Rican specimen of this species was taken at Bagaces at a point where one of the streets enters the Pan-American Highway. It was in loose earth below a flat rock. It is presumably a juvenile specimen, its total length being 76 millimeters, of which five are in the tail. The tail turns down and ends in a rather sharp spine.

The dorsal and lateral surfaces are dark blackish but when submerged in a clear liquid it shows a very faint suggestion of darker medial areas on the scalerows. This probably is not an adult condition since the type displays no trace of such markings. This specimen differs but little from the type in the characters of the squama-

* Taylor *l. c.* p. 540, couplet 22 states: "only spine on tail cream"; and "tail in tail length, 14"; This should read, cream spot on tail including about four transverse scale rows; (as stated on p. 533) and, tail in tail length 16. Dunn and Saxe 1950 point out this error.

tion. The conformation of the head scutes is practically identical with that shown in the figure of the type—the nasal is completely divided, a supraocular bears the same relation to the rostral and anterior (superior) nasal, the labials, parietals, frontal and interparietals likewise, are practically identical proportionately. The eye is scarcely discernible in the ocular. The last labial and the ocular have their lower parts whitish and the infralabials are light. The anterior part of the snout is dark gray. The anterior part of the venter is grayish white, growing darker posteriorly.

There are 14 scale-rows about body and 10 about tail and approximately 245 transverse scale-rows from the rostral to the tip of the tail. There are 19 subcaudals. The anal is a large single scale preceded by a narrow, transversely widened scute, at least as wide as the anal.

The width of the head is 1.6 mm. and of the body 1.7 mm.*

The ratio of tail length to total length is 15; the ratio of the width of the body to the total length is 47.5. In the type these two ratios are 18.9 and 60 respectively. The scales from lip to vent number 225. It will be necessary to verify the number of scales in the type as the statement "259 scales from snout to vent" is probably intended for "snout to tip of tail." Even if this were true the present specimen has fewer transverse scale rows on the body than the type.

This species is not a member of the *albifrons* group.

Conophis lineatus nevermanni Dunn

(Fig. 16)

Conophis nevermanni Dunn, Copeia 1937, no. 4, pp. 214-215 (type locality, Río Poás de Aserri [near San José] Costa Rica); Taylor, Univ. Kansas Sci. Bull., vol. 34, pt. 1, Oct. 1, 1951, p. 145; Savage, Trans. Kansas Acad. Sci., vol. 52, no. 4, 1949, pp. 484.

A specimen of this species, KUMNH No. 35630, taken from under a stone in an open meadow, two miles south of Hotel Yomale, some 32 kilometers north of Barranca, Puntarenas Province, but in, or near, the boundary of Guanacaste Province, is referred to this species with some hesitancy. The markings and scale characters of the specimen follow:

The venter is ivory to yellow ivory with a row of black dots on the lateral part of ventrals throughout the length of the body. A black line running through the middle of the first (outer) scale-row

* The width of the body in the type is given as 305 millimeters, an obvious typographical error for 3.05.

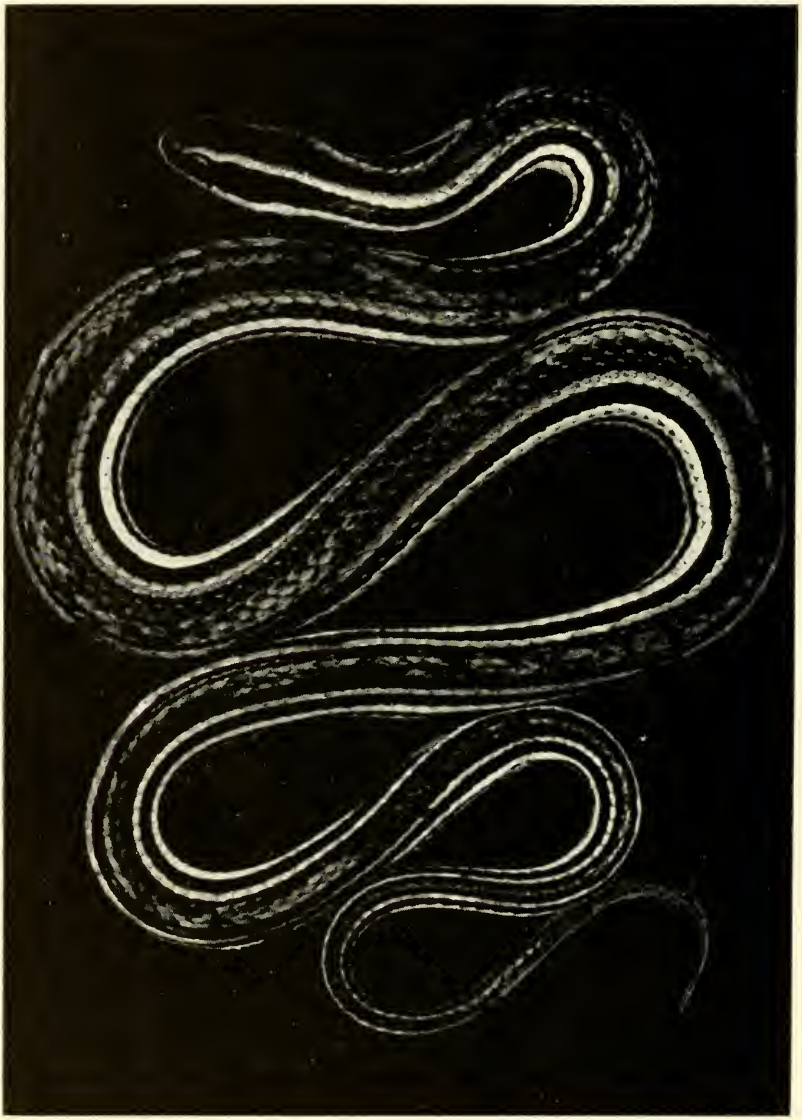

FIG. 16. *Conophis lineatus nevermanni* Dunn. KUMNH No. 35630; about 32 km. N Barranca, near the boundary of Guanacaste and Puntarenas Provinces, Costa Rica.

is continued a little past the base of the tail. Above this, an ivory line covering one whole scale-row and the edges of adjoining scale-rows runs from the tip of the snout along the body and onto the tail bearing a series of black dots along the latter half of the body and

posteriorly is lost in the ventrolateral color of tail. The broad black band, beginning on the tip of the snout runs along the neck where it covers about four scales, then narrows, occupying all except the outermost edges of the third and fourth rows. A lighter streak is present in the middle of this stripe, evident only for a part of its length. Above this is an olive-gray stripe on the fifth and sixth rows, becoming lighter cream or ivory posteriorly, and throughout it is lighter on the lower part of the fifth row. This is bordered above by a narrow black line not more than one scale wide, on the seventh row anteriorly, on the sixth posteriorly. The five rows (four posteriorly) lying between the seventh row and its fellow of the opposite side are blackish on the back of the head and neck, but become olive-gray more posteriorly. The color is not uniform. The median dorsal row has a line of dashlike black marks, and a row of darker flecks occur on the edges of the eighth and ninth rows of each side. The upper part of the supralabials have a cream or ivory line with a ragged lower edge while the lower part of the labials show pigmented areas of black, the color not solid. The infralabials, chin, and part of throat pigmented with brown, enclosing two short rows of rounded ivory spots.

The following scale characteristics obtain: ventrals 169, subcaudals 70, anals 2, supralabials 8, the fourth and fifth enter orbit; infralabials 9, preocular 1, postoculars 2, anterior temporals 2, scale rows, 21-19-19-17.

This form definitely is not *Conophis lineatus dunni* Smith from Nicaragua and it is possible that it is not identical with Dunn's *nevermanni*. The later is very briefly described and the type is said to be in Dunn's private collection.

Leptodeira sp.

Hypsiglena torquata torquata Taylor, Univ. Kansas Sci. Bull., vol. 36, pt. 2, no. 11, July 15, 1954, p. 712-713, fig. 9.

In the above listed publication I reported and figured a juvenile snake as a species of *Hypsiglena*. The specimen had been badly injured, the head having been subjected to extensive injury in the palatal and dental regions. After the publication I was struck by the large number of subcaudals, a character which should have caused me to question the association with *Hypsiglena* from the first. After careful re-examination of the specimen, a fragment of the posterior mandible was found showing the base of a broken, enlarged, posterior, grooved tooth. This fact, together with the scale characters and the high subcaudal count, places the specimen in the genus *Leptodeira*, as now understood.

I think it unwise to attempt to allocate the form specifically owing to its mutilated condition and the fading of the colors and markings. New material should be at hand before this is undertaken.

Coniophanes piceivittis piceivittis Cope

(Fig. 17)

Coniophanes piceivittis Cope, Proc. Amer. Philos. Soc., vol. 11, July 1869, pp. 149-150 (type locality, Chihuitán, Oaxaca, Mexico); Bailey, Papers Michigan Acad. Sci. Arts, Lett., vol. 24, pt. II, 1938 (1939), pp. 29-31, pl. 2, fig. 2 (Bebedero, Costa Rica); Taylor, Univ. Kansas Sci. Bull., vol. 34, pt. 1, no. 1, Oct. 1, 1941, p. 142.

Coniophanes piceivittis piceivittis Mertens, Abh. senckenb. naturf. Gesel., no. 487, 1952, p. 61 (San Salvador).

In my paper on Costa Rican serpents I suggested that Bailey's record for this species in Costa Rica might be questioned. The finding of two specimens in western Costa Rica, four miles north of Hda. Santa Rosa (on Pan-American Highway), Guanacaste Province, in the summer of 1954, verifies its presence in the Country. These were taken by me in the vicinity of a small stream, in a pile of chips about the base of a recently felled tree. The arrangements of the markings on the body and head are as follows: first to third scale-rows with edge of the adjoining row, lavender cream, peppered lightly with lavender brown; anteriorly and posteriorly only two whole scale-rows are involved; above this on the fourth to eighth scale-rows a broad straight-edged black stripe which begins on the rostral and runs back, covering upper part of labials, and on neck, covers four whole scale-rows and the adjoining halves of two others; it gradually narrows to three rows and parts of the adjoining rows on the posterior parts of the body; a narrow, irregularly edged, cream line begins on rostral, passes above eye along edge of parietal to the neck where the edges become straight, and continues on to tail, covering the ninth whole row and parts of the adjoining scale-rows. The median black stripe covers the top of the head then continues to tail, covering five median scale-rows and the adjoining edges of two others, but reduces to three and two half rows on posterior part of body. The supralabials are cream, dark-edged above with a splashed black spot on the lower part of each scale. The infralabials, chinshields and scales at beginning of throat flecked with black. The ventrals are uniformly cream except for a few darker flecks on their upturned lateral edges. The second specimen agrees in rather accurate detail with the first.

Scale characters of these specimens, KUMNH No. 23553 and 23554 follows. Ventrals 165, 163; subcaudals 62 +, 83; scale rows 23, 25, 25, 19; 23, 25, 25, 19; supralabials, 8-8, 8-8; infralabials 10-10,

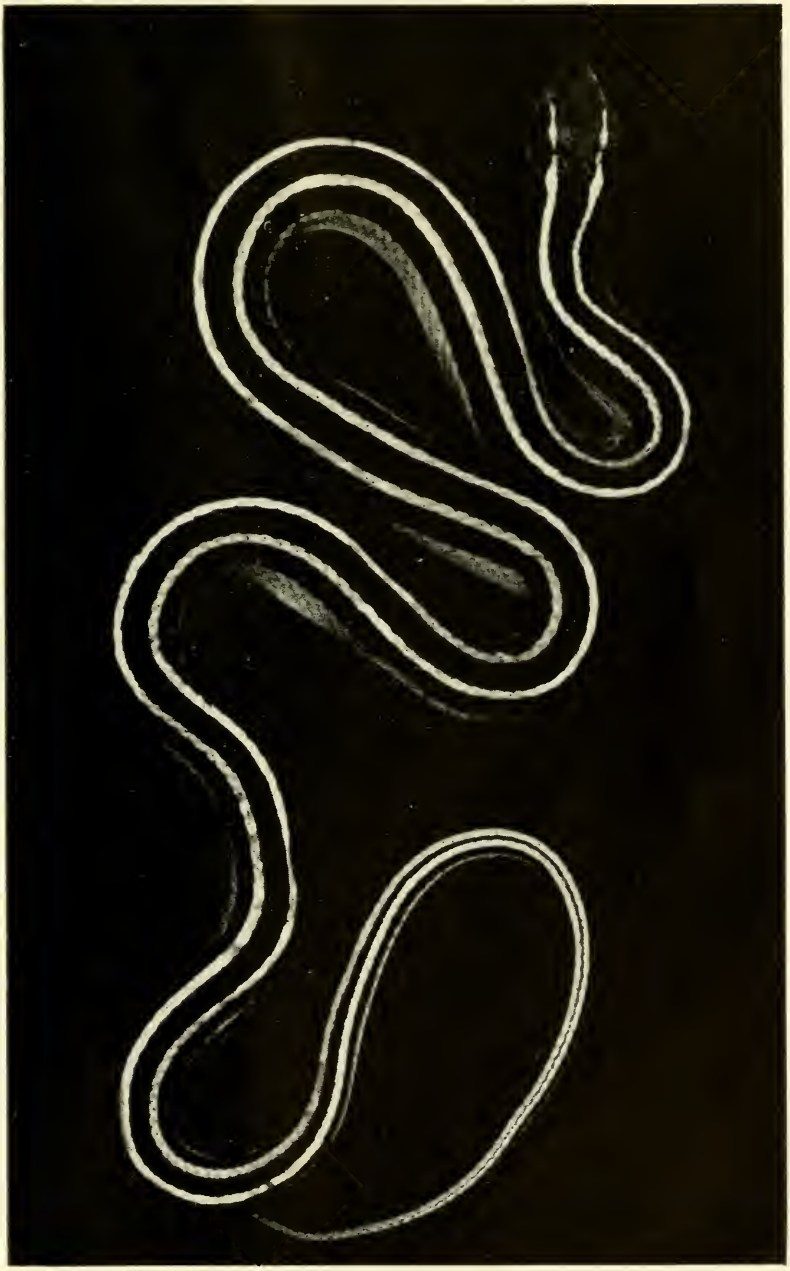

Fig. 17. *Coniophanes piceivittis piceivittis* Cope. KUMNH No. 23553, 4 mi. N Hda. Santa Rosa (on Pan-American Highway), Guanacaste, Costa Rica. About natural size.

10-10; preoculars 2-2; postoculars 2-2; temporals $1 + 2 + 4$, $1 + 2 + 3$; the scales on sides at least three inches in front and behind level of vent strongly keeled or tubercled; the anal scale is divided.

Neopareas bicolor Günther

(Figs. 18, 19)

Neopareas bicolor Günther, Biologia Centrali-Americana; Reptilia and Batrachia, July 1895, pp. 178-179, pl. 56, fig. C (type locality, Chontales Mines, Nicaragua); Taylor, Univ. Kansas Sci. Bull., vol. 34, 1951, p. 66 (incorrectly spelled *Neoparias*).

Leptognathus bicolor Boulenger, Catalogue of the Snakes in the British Museum, vol. 3, 1896, p. 460.

A specimen of this genus was obtained at Turrialba at the Inter-American Institute of Agriculture in 1952. The animal had gained admittance to the building of the Institute and was captured in one of the dormitories. The characters of this specimen are as follows:

Description of KUMNH No. 31920: Body strongly compressed; head short, the width of the neck (2.6 mm.) in width of head (7 mm.) 2.7 times; rostral wider than high, narrowly visible above as a broad triangle, the lower part of scale with an arched depression; internasals small, about one third area of the prefrontals, much wider than long, their common suture half that between the prefrontals; latter scales broader than long, touching nasal, loreal, and preocular laterally; both prefrontals and internasals with minute pustular rugosities; frontal pentagonal, shield-shaped, the anterior edge straight, transverse, its length (3.2 mm.) greater than its width (2.8 mm.); supraoculars narrowed anteriorly, widened posteriorly, not reaching back as far as frontal, but extending somewhat farther forward; parietals large, longer than frontal, their length equal to their distance from the internasals. Nasal single, irregular in shape, the back edge of the scale elevated and somewhat excavated behind nostril; loreal large, higher than long, bordering orbit below the smaller preocular; three postoculars, the lower smallest; temporals, $2 + 2 + 3$, $\frac{1}{2} + \frac{1+2}{1}$; supralabials 10-9, the fourth to seventh (third to sixth) entering orbit; mental small, much narrower than the rostral; infralabials, 11-12, first five touching the large azygos scale on chin, two (three) labials touching second azygos; third and fourth azygos each in contact with two labials; first pair of labials fused behind the mental; labials and azygos scales on chin with minute rugosities (male character). Eye very large, its diameter (2.5 mm.) greater than length of snout (2.1 mm. medial measurement).

Scales smooth, lacking pits; scale formula: 19 (back of head),

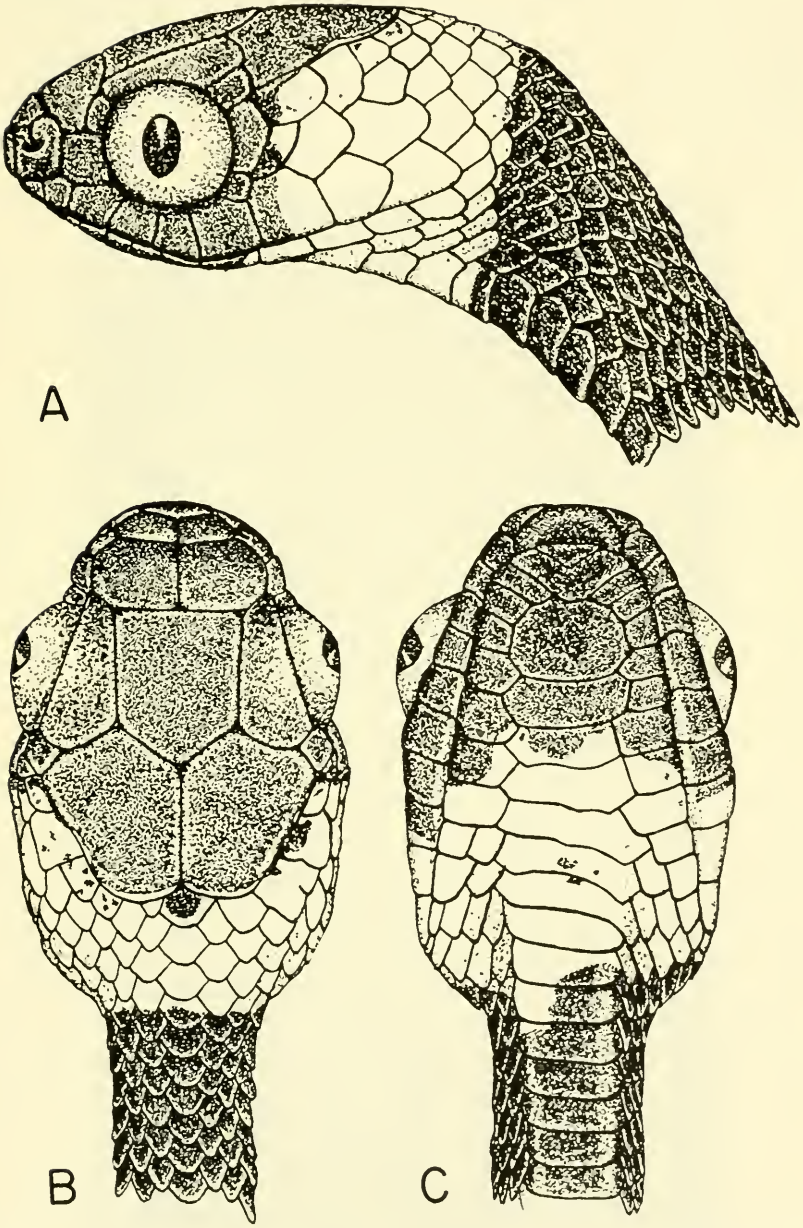

Fig. 18. *Ncopareas bicolor* Günther. A. Head, lateral view. B. Head, dorsal view. C. Head, ventral view. All much enlarged.

15, 15, 15; the median dorsal row not or but scarcely larger than adjoining rows; two broadened, dorsal scales above anal region; scales behind the fourth azygos not differentiated from typical ventrals and the ventral count begins at that point: ventrals, 186; anal single; subcaudals, 118; total ventral-subcaudal count 304.

Color in preservative: Above black, banded with cream; the first

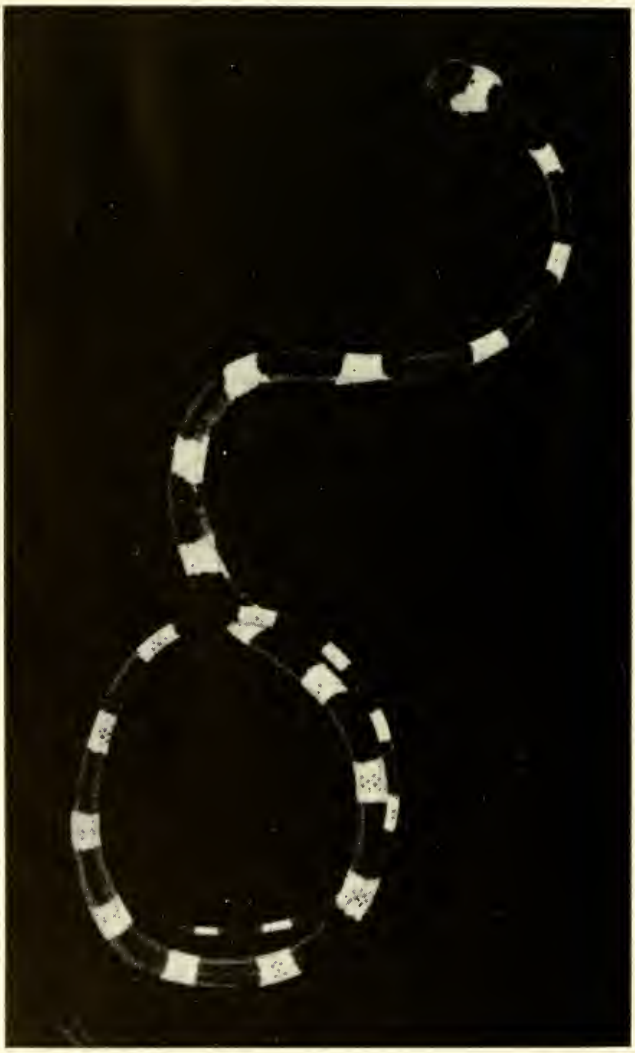

FIG. 19. *Neopareas bicolor* Günther. KUMNH No. 31920, Turrialba, Costa Rica; actual total length, 334 mm.

band on back of head about four scale-rows wide, dorsally widening laterally to include the temporals, posterior supra- and infralabials, the posterior azygos shield on chin and the following five ventrals; a discrete black spot on a somewhat enlarged median postparietal scale and a few very small dots of black on upper temporals; cream bands on head and body 16, dorsally covering approximately four transverse scale-rows, widening on the sides and covering five to six ventrals; the intervening black color covers ten scale-rows anteriorly then eight or nine in middle region and reducing to seven posteriorly on body; all becoming narrower on sides and venter; nine cream bands on tail, all, except first cream band, have series of black dorsal flecks.

Measurements in mm.: Total length, 334; snout to vent, 227; tail, 107; width of head, 7; length of head, 11.

Dentition: The dentition of this species is remarkable. The high anterior, dentary teeth, surrounded by gums, form two high longitudinal ridges in the anterior part of the floor of the mouth that fit into deep depressions in the anterior part of the palate; the lower jaws lie in the middle of the floor of the mouth separated by a distance of only 1.5 millimeters for much of their length. The sides of the mouth-floor are muscular. The maxillaries lie horizontal, the anterior teeth somewhat erect, the posterior curving, smaller than the teeth on dentaries. Maxillary teeth, 21, decreasing in size posteriorly; dentary teeth, 22, decreasing in size posteriorly; palatine and pterygoid teeth present.

Remarks: Günther, who described the genus and species had only a single specimen. The general characteristics of the teeth were not mentioned except to state that they were small and ungrooved. From data given by Günther and Boulenger the type specimen differs from my specimen as follows: twenty more scales in the total ventral-subcaudal count (324-304); two more encircling white rings (27-25); internasals larger, two thirds length of prefrontals (half length); frontal as long as broad (longer than broad); third azygos scale followed by a pair (fourth azygos scale undivided); cream bands immaculate (bands bearing numerous dorsal black flecks).

Since I did not see the specimen before preservation, it is possible that the light bands were originally pink or red. The collector "believed that such was the case, but was uncertain."

The amount of variation to be expected is unknown. A series may show constancy in the variations mentioned above.

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